COMBUSTION

DEVOTED TO THE ADVANCEMENT OE STEAM PLANT DESIGN AND OPERATION

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GERALD S. CARRICK
General Representative

ALFRED D. BLAKE
Editor

THOMAS E. HANLEY
Circulation Manager

GLENN R. FRYLING
Assistant Editor

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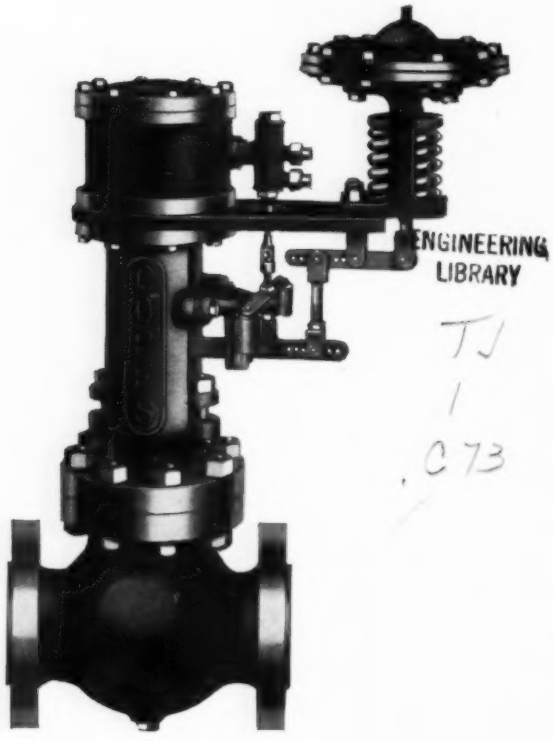

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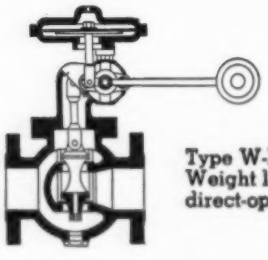

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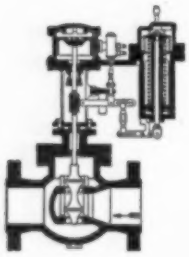

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Editorials

Sewaren

The long anticipated story on Sewaren Generating Station of the Public Service Electric and Gas Company has now been made available and should command more than passing interest. It represents post-war design embodying many advanced yet conservative features, some of which have been employed in other plants but not all in any previous installation. The station is well worth visiting.

Being part of an extensive and integrated system it was possible to employ large units and to follow completely the unit system of one boiler, with its auxiliaries, per turbine. Very considerable savings in construction cost were made through adoption of the semi-outdoor type of boiler plant, and the overall cost of $132 per kilowatt of nameplate rating, based on four units, is very moderate under present conditions. Despite a relatively small building volume per kilowatt and only two operating levels, there is no crowding of equipment; and for a plant of its capacity the operating force is not large—around a hundred men in all.

Sewaren has the distinction of being the first central station to go into service with a steam temperature of 1050 F. Although the pressure of 1500 psi may preclude it from carrying the blue ribbon as the most efficient plant from a Btu standpoint, it is almost certain to achieve front rank, especially when the fourth, or reheat unit, is in service. The calculated net station heat rate for the entire station under those conditions is around 9700 Btu per net kilowatt-hour, but this figure may ultimately be bettered in service.

Synthetic Fuel Production

Fuel is an item of major concern in power plant operation and matters that concern its production are of vital interest to those in the power plant field. In many areas plants are designed to burn multiple fuels in order to insure continuity of operation during periods of shortage and to take advantage of favorable price differentials.

At the present time in this country the supply of both solid and liquid fuels appears to be adequate. Recent cuts in the price of heavy fuel oil have given it a competitive advantage over coal in some areas. But what of the future?

Dire predictions of the exhaustion of the supply of oil have been made so many times that they are justifiably greeted with a certain amount of skepticism. New oil fields seem to be discovered with sufficient regularity to discredit prophets of scarcity. And yet there are those in the power field who cannot forget the necessity for emergency conversion from oil to coal during World War II and the postwar oil shortage, seemingly now ended.

Synthetic fuels are one possible answer to an assured future supply. In a time of declining prices coupled with a fuel surplus, temporary though these conditions may be, there is understandably little enthusiasm to embark upon the major capital investments and the technological risks of establishing a synthetic fuel industry on a large scale. While government aid in research and in establishing pilot plants is an accomplished fact, it has been proposed that government subsidies be made to meet this need. The question remains, can a synthetic fuel industry be established in this country without awaiting the stress of a national emergency and the crisis of a major fuel shortage?

Reinjection of Fly Ash

Experience gained through the marked increase in spreader-stoker firing, with its inherently high carryover, has led to widespread application of dust collectors to such installations.

Since this carryover runs high in combustible, reburning has become popular, but the extent to which this may be employed economically is open to question.

There can be little argument as to the desirability of reinjecting into the furnace the collections from hoppers located under the boiler passes. These are made up mostly of the larger particles which run relatively high in combustible content, and the gain through reburning is usually substantial.

However, an efficient mechanical dust collector will collect 90 per cent, or more, of the fines which if reinjected into the furnace multiply the dust loading of the furnace gases several times. The result is likely to be excessive stack discharge and a tendency to erode boiler tubes, economizer tubes, baffles, etc. Also, if the coal has a low ash-fusion temperature, troublesome slagging may occur. This means added maintenance, besides the greater initial and operating cost.

It is obvious, therefore, before deciding upon the extent of reburning, that the gain in efficiency be carefully weighed against the other factors mentioned.

Sewaren Generating Station as seen from water side

Mechanical Features of SEWAREN GENERATING STATION

SEWAREN Generating Station of the Public Service Electric and Gas Company, formally opened on June 8, will, when completed, be the largest of five stations on that company's system. Located on the Arthur Kill, some three miles above Perth Amboy, N. J., and opposite the Staten Island shore, it at present contains two 100,000-kw units. A third of like capacity is scheduled for operation this fall and a fourth, of 125,000 kw, is on order. The new station feeds the Company's 132-kv transmission system supplying the heavy industrial area in northern New Jersey with extensions to Trenton and Camden in the South, and also directly feeds a 26-kv transmission to the Bayway and the Metuchen switching stations.

Not only is Sewaren the first completely new generating station to be built in the New York Metropolitan area in over twenty years, but it incorporates many advanced features of particular interest. Among these are semi-outdoor construction for the boilers and their auxiliaries; strict adherence to the unit arrangement of one boiler per turbine without cross-connections to other units; two-level operation; throttle steam conditions of 1500 psi, 1050 F; eight stages of extraction for feedwater heating; reheat to 1000 F on the fourth unit; central control of units in pairs; building ventilation under slight pressure for cleanliness; relatively small building volume and small operating force per kilowatt of capacity; and an initial cost of $132 per kilowatt, based on the four units. In fact, according to F. P. Fairchild, chief engineer, about a million dollars of initial cost of the first three units was saved by the semi-outdoor type of construction.

Laid out on the unit principle, this new electric generating station of the Public Service Electric and Gas Company is of the semi-outdoor type and employs steam conditions of 1500 psi, 1050 F at the turbine throttle. It is the first station to operate at this steam temperature. The first three units are straight condensing, rated at 100,000 kw, but the fourth, now on order and of 125,000-kw rating, will employ reheat to 1000 F. There are eight stages of extraction for feedwater heating, and either oil or pulverized coal may be burned. The cost per kilowatt of installed capacity is $132, based on four units.

At the time of beginning construction the site was largely a salt marsh and some 400,000 cu yd of fill was obtained from dredging operations to provide a 30-ft draft in front of the dock for fuel delivery and 20 ft of water at the intakes to the screens.

The power house and other structures, except the switching station, are carried on closely spaced 25- to 30-ft piles capped by a concrete mat in which one bag of fly ash was mixed with five bags of cement.

This resulted in a concrete having a minimum strength of 3500 psi after 28 days, or an average strength of about 4000 psi.

The main building, which houses the service rooms, turbine hall, control rooms and boiler fronts, is faced with gray brick trimmed with limestone, and has the window frames of aluminum, thus providing a simple yet most attractive appearance. To provide for possible future extension the west wall is of corrugated transite secured to steel girts. The turbine hall roof is supported by arched girders instead of the usual open-truss construction and the interior walls are faced with glazed tile. Special treatments are accorded various other areas.

All outdoor casings of boilers, auxiliaries, ducts, etc., are aluminum painted and balconies at various boiler levels are provided for soot-blower operation and other operating convenience.

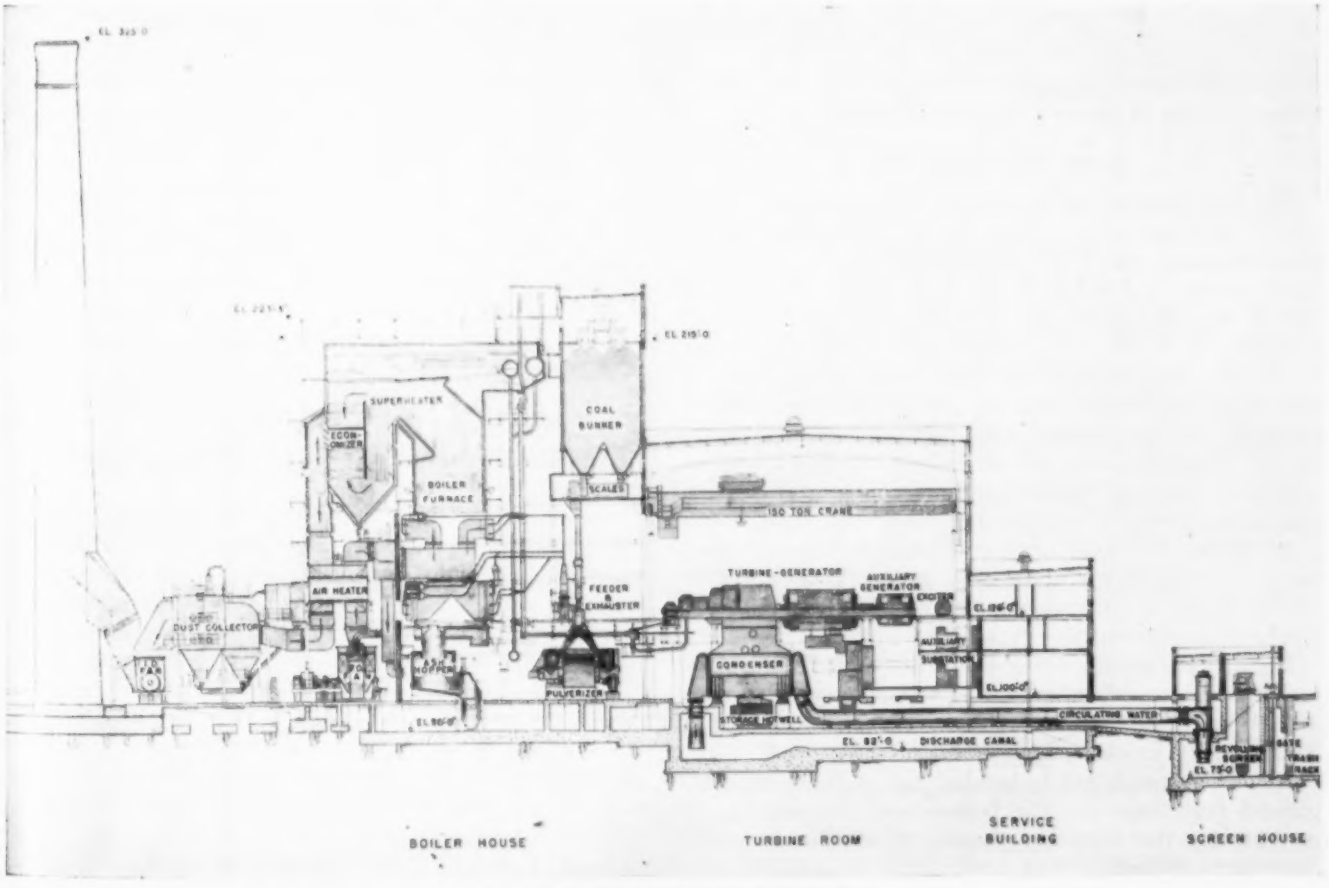
The ample space surrounding the station permits appropriate landscaping.

Fuel Handling

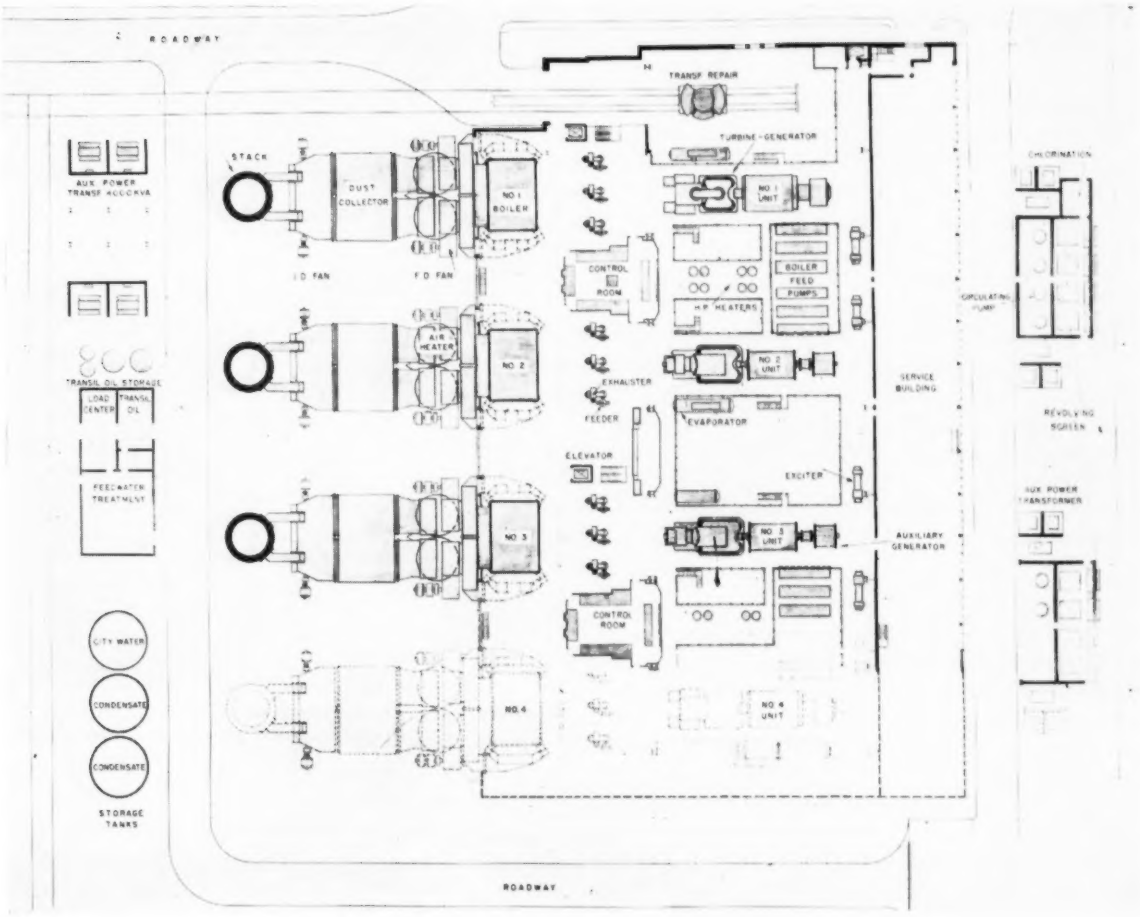
Both oil and coal are delivered to the plant by barge, the former being pumped to a 125,000-bbl fuel-oil tank located north of the main building. The coal-handling equipment consists of an unloading tower on the dock, from which a conveyor delivers to a Bradford breaker in the breaker house. From here it is conveyed either to the station bunker or to a swing boom tower for yard storage. The conveyor system has a capacity of 600 tons per hr. Tractor-drawn carryalls transport the coal from the initial pile to yard storage or reclaim it to a hopper feeding a return conveyor to the breaker house. This hopper can also receive coal from railroad cars.

Property layout showing relative locations of generating station, coal-handling equipment and transformer yard

Each boiler has its own 1800-ton bunker from which coal drops through Stock gates to Richardson automatic weighing scales with hoppers that feed the coal to stainless steel pipes supplying the pulverizer feeders. Vibrators are provided to minimize clogging of wet coal.



Sectional elevation through station



Plan of main operating floor

A movable shuttle conveyor can be employed to empty a bunker in case of fire or a prolonged outage.

Steam Generating Units

The first three steam generating units are alike. They are of the three-drum Combustion Engineering-Superheater radiant type, rated at 850,000 lb of steam per hour continuously or 950,000 lb for four hours, at 1500 psi, 1050 F throttle conditions. The completely water-cooled furnaces, of 52,450 cu ft volume, are of the continuous-discharge, slagging-bottom type, tangentially fired at two levels with combination pulverized coal and oil burners. These burners are vertically adjustable to permit positioning of the turbulent burning zone for optimum slagging conditions and control of the gas temperature leaving the furnace. Each unit incorporates a 31,800-sq ft two-stage pendant-type Elesco superheater, a continuous-tube counterflow economizer of 39,600 sq ft in three sections and two 104,350-sq ft Ljungstrom regenerative-type air preheaters.

Because of the steam temperature involved, the highest temperature superheater elements (finishing-off section) are of steel alloyed with 19 per cent chromium and 11 per cent nickel, titanium stabilized.

All draft equipment is located out-of-doors near the ground level between the boilers and the stacks. It consists for the first three units, of six variable-speed American Blower forced-draft fans of 123,000 cfm capacity driven by constant-speed motors through hydraulic couplings with continuous pump control; also six 221,000-cfm induced-draft fans of the same make, two driven through hydraulic couplings and four with the gas flow controlled by inlet-louver dampers. All the fan bearings are air-cooled because of the outdoor location.

An automatic combustion control system of the Hagan type is employed to control the combustion rate, furnace draft and fuel-air ratio. The feed pumps are under Bailey three-element control and an L & N temperature controller automatically regulates the superheated steam temperature by positioning the electrically operated superheater bypass damper. Tilting of the top set of four burners is accomplished by remote manual control from the control room, and the lower sets are adjusted manually at the burners.

Compressed air is used for soot blowing. Retractable units, operating at 250 psi, are employed for the furnace walls, the second superheater stage and the air preheater; whereas puff-type revolving blowers clean the first stage of the superheater and the economizer with 320 psi air. Automatic sequential operation of these blowers is controlled and indicated in the control room. The system is of Diamond design and compressed air for this purpose is supplied by two single-stage, high-pressure (120- to 500-psi) 1000-cfm Ingersoll-Rand compressors and two Fuller two-stage, low-pressure compressors of 1035 cfm capacity at 120 psi.

Each of the first three steam generating units is served by three 37,400-lb-per-hr Hardinge ball mills.

A 225-ft ground-supported, radial-brick stack of Kellogg design serves each boiler. These stacks are lined with brick which is self-supporting for the lower 125 ft and is carried on corbels at 33-ft intervals.

A permanent, stationary acid-cleaning system, consisting of tanks, pumps and piping, has been installed for internally cleaning the boilers.

The fourth steam generating unit will be similar to the first three except that the furnace will be somewhat larger and it will incorporate a pendant-type reheater section designed for 1000-F steam. Auxiliary equipment for this unit has not yet been announced.

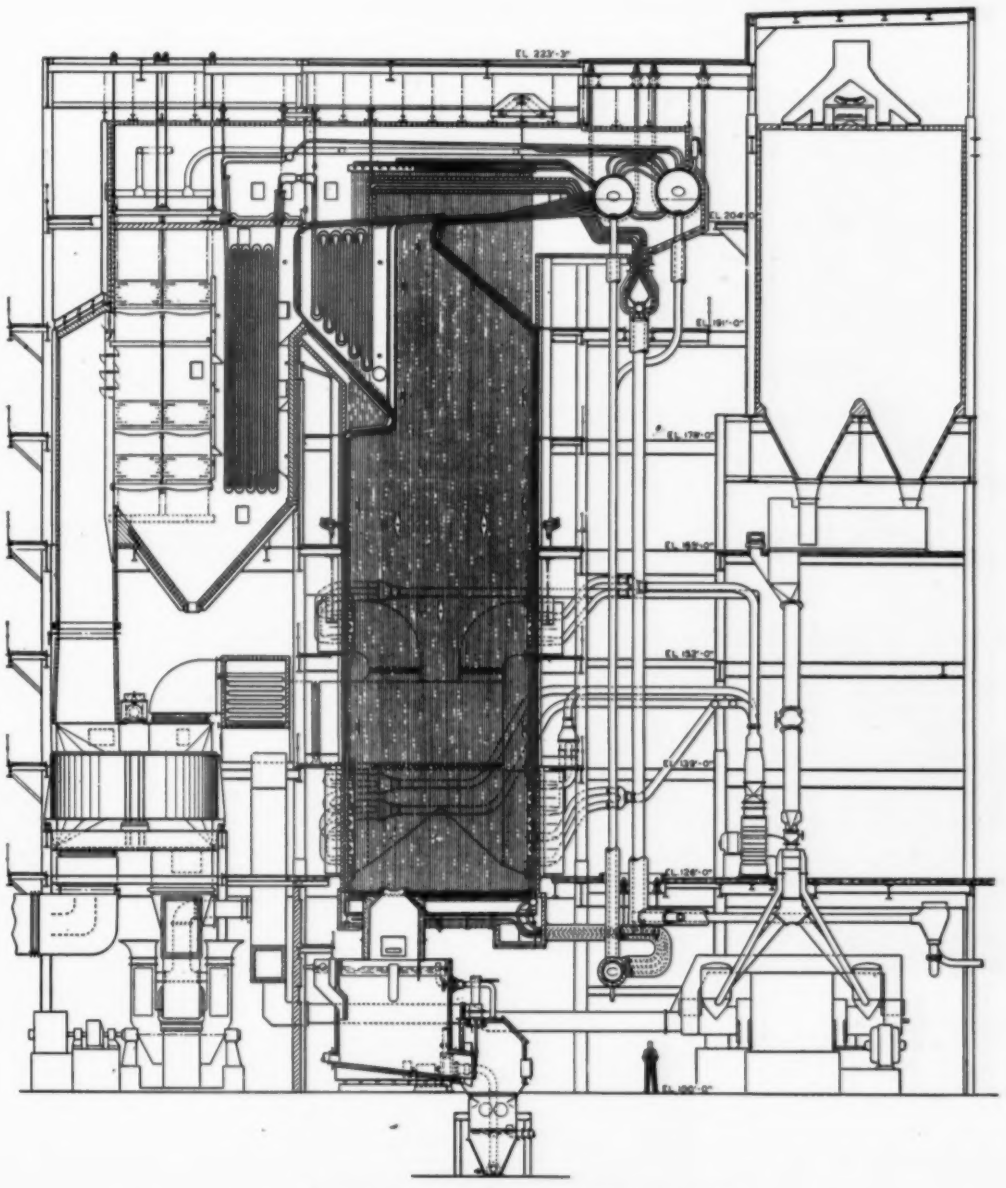
Dust Collection and Ash Disposal

The dust collecting system, of Western Precipitation design, combines multicyclones and electrostatic precipitators in series, and is located at near ground level between the air preheater gas outlet and the induced-draft fan. Flue gas leaving the air preheater first passes through the cyclones for removal of the coarser particles and then to the electrostatic precipitators for removal of the fine dust. Hoppers located beneath the collector deliver the fly ash to a Redler conveyor which transports it to a dust pump, thence to a storage silo in the breaker house, for possible sale or to the ash-disposal area by means of the ash-disposal system.

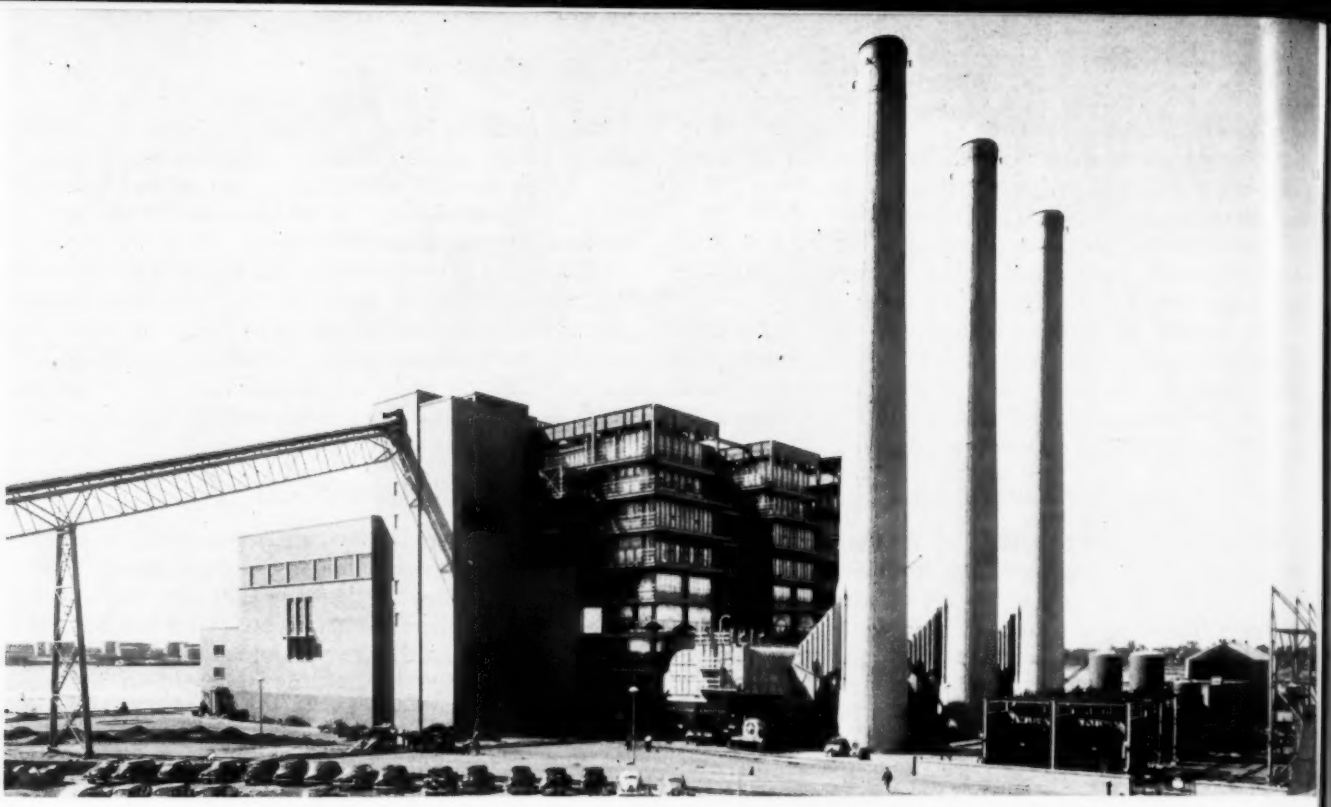
Molten slag from the furnace is handled by an Allen-Sherman-Hoff system, from the slag spout it flows past disintegrating nozzles into water in the ash hopper which accommodates about twelve hours accumulation. At intervals the contents are sluiced into the sump tank which contains a clinker grinder, and then pumped to the disposal area.

Boiler Feed

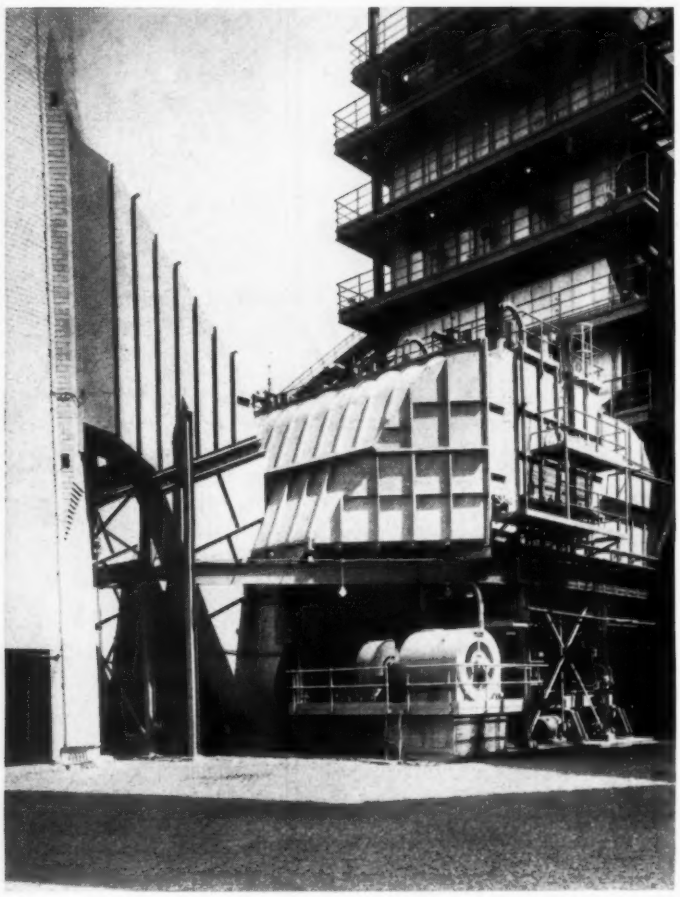
Condensate from the condenser hotwell is handled by re-entry condensate-booster pumps which send it through various heat-exchangers that pick up heat from the generator coolers, oil coolers, etc., after which it enters the second stage of this pump and is forced through four low-pressure closed heaters, as indicated in the heat-balance diagram. From the last of these the condensate



Cross-section of steam generating unit



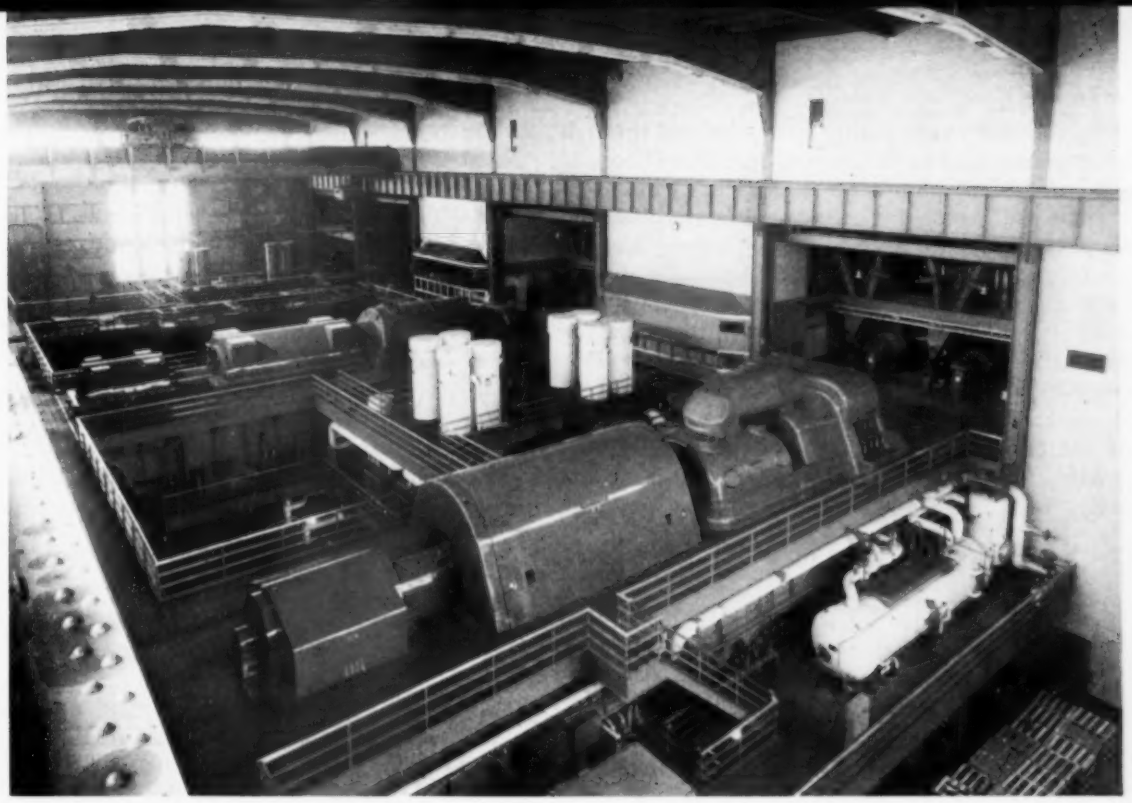
Rear of station showing steam generating units and stacks



Induced-draft fan and dust collector at rear of one of the boilers

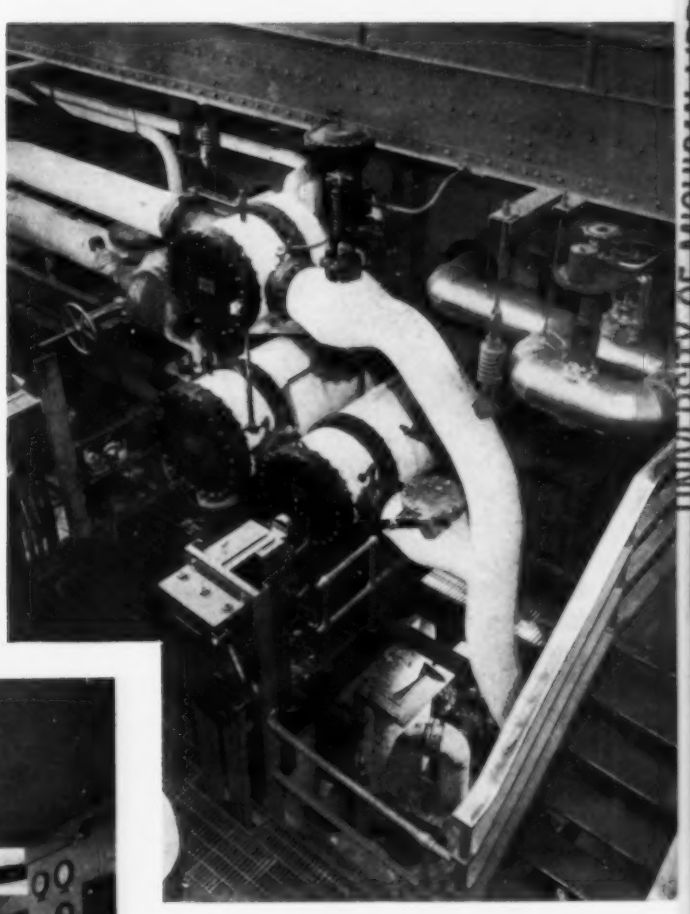
Random Views In and Around SEWAREN Generating Station

Coal-handling system



Turbine room with first two units

Condenser outlet water boxes



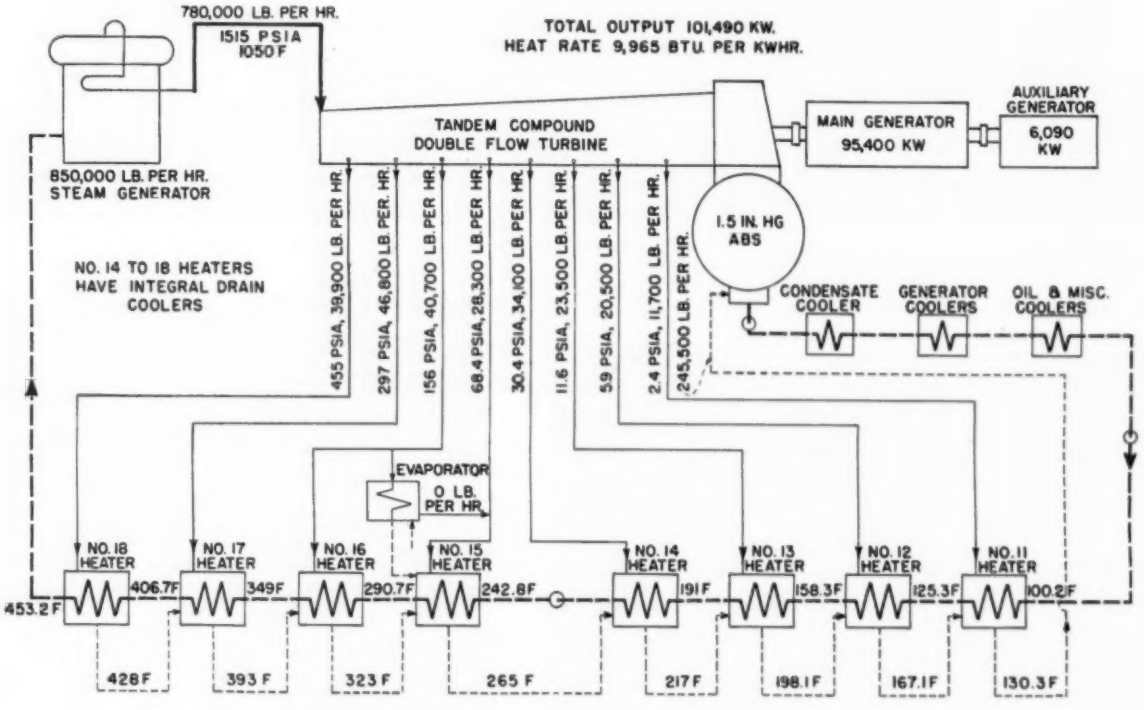
Feedwater heaters in condenser neck

One part of the control room

is taken by the boiler-feed pumps and delivered through four high-pressure heaters to the economizer. There are three eight-stage feed pumps for each steam generating unit. These are motor-driven through variable-speed hydraulic couplings and are designed to pump 1115 gpm against a total head of 4680 ft. The pumps are of such capacity that one condensate-booster pump and two boiler-feed pumps are sufficient to meet full load on the steam generating unit.

Makeup is provided by one single-effect evaporator for each unit. This takes steam from the third bleed point of the turbine and discharges vapor to the next lower heater in the cycle. Evaporator feed is zeolite treated city water. In addition to supplying makeup, in the double-flow, low-pressure cylinder. The blades in the high-temperature region are of 13 per cent chromium steel and the Curtis stage nozzles are of 18–8 stainless steel. The high-pressure casing contains $2^1/_4$ per cent chromium and 1 per cent molybdenum.

Nos. 2 and 3 turbine-generators are General Electric machines having 18 high-pressure stages and five stages in the triple-flow, low-pressure element. The blades in the highest temperature region are of steel containing 12 per cent chromium, 5 per cent cobalt, 3 per cent tungsten and 0.15 per cent molybdenum. The inner shell of the high-pressure element is of steel containing 17 per cent chromium, 14 per cent nickel and 2 per cent molybdenum, columbium stabilized.



Heat balance diagram of Unit No. 1

the evaporators normally supply steam for heating fuel oil and chemicals as well as building heating. Provision has been made to supply chemicals for feedwater treatment to the suction of the boiler-feed pumps or to the boiler drums.

Turbine-Generator Equipment

Two of the first three turbine-generators are in service, one having gone into commercial operation November 30, 1948, and the other on December 1, 1948. The third is scheduled to go into service this coming fall.

All three are single-shaft, tandem-compound 3600-rpm units rated at 100,000 kw (nominal) with throttle steam of 1500 psi, 1050 F. An auxiliary generator of 7500 kw is connected to the outboard end of each generator; that is, each auxiliary generator supplies the auxiliaries of its own unit, although the 2400-volt auxiliary bus of each unit can be fed from an outside source if necessary.

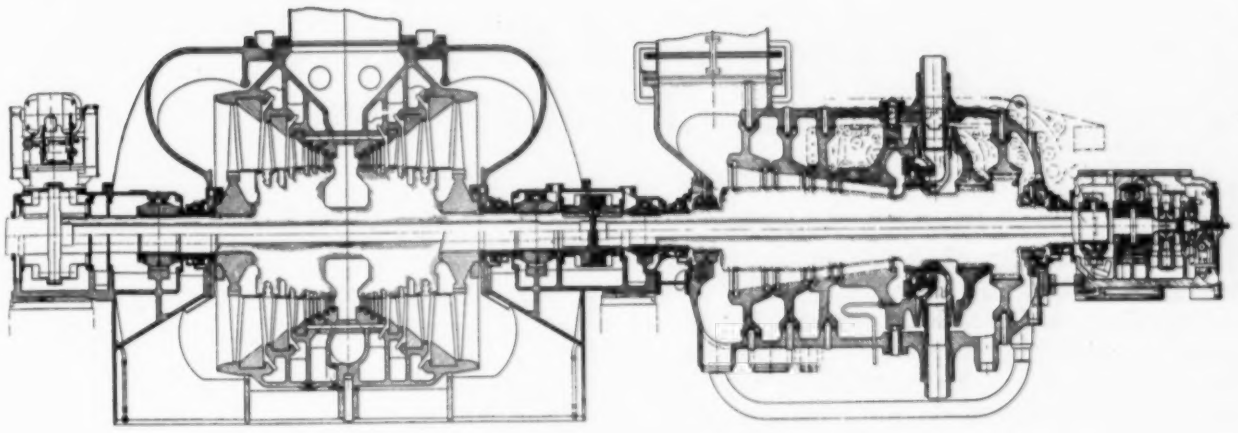
No. 1 turbine-generator is a Westinghouse machine having twenty-five high-pressure stages and seven stages

Eight stages of extraction are employed for feedwater heating which accounts for about a third of the steam passing the throttle.

No. 4 turbine-generator, now building, will be a Westinghouse unit having a rating of 125,000-kw and will differ from No. 1 in that it will have a triple-flow, low-pressure element and employ 1000-F reheat. Initial steam conditions will be the same as for the other units.

The condensers are the single-pass Foster Wheeler design with divided water boxes having bottom inlet and outlet connections. The welded steel shell is spring-supported and its extension neck is welded to the turbine exhaust connection. Each condenser has two Kinney positive-displacement, rotating vacuum pumps for removal of non-condensible gases in place of the more common steam-jet ejectors. These are also used to evacuate the steam space of the condenser when starting.

Circulating water for each condenser is supplied by two motor-driven, vertical, mixed-flow pumps of 47,000-gpm capacity at 17-ft total head. The motors for units



Section through turbine-generators Nos. 2 and 3

1 and 2 are located in the screen house at the bulkhead, but those for units 3 and 4 will be outside. All circulating water is chlorinated as it flows through the trash racks and traveling screens.

Piping

The main steam and high-pressure boiler feed piping is chrome-moly alloy steel (3 per cent chrome, 1 per cent molybdenum) and welded, the only flanged joints exposed to 1050-F steam being those in the steam admission piping from the turbine control valves to the top half of the high-pressure turbine casing. For the high-pressure boiler feed piping valve bonnets are of the pressure-sealing, breechblock design without a bolted closure.

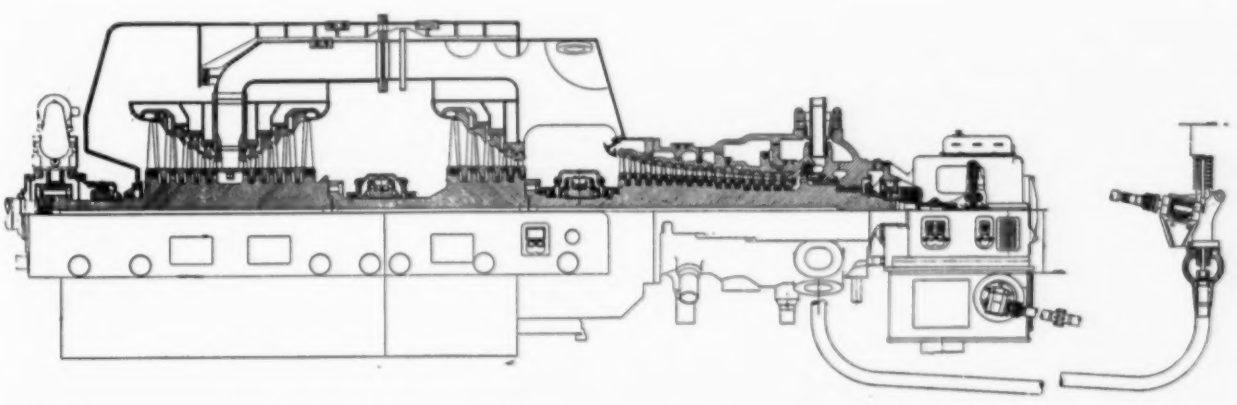
There are no valves between the boiler and the turbine stop valves. Since the turbine stop valves are of stainless steel which expands about 50 per cent more than the ferritic steel of the pipe, the joint had to be made by a new method known as the "Kelcaloy Process," developed by The M. W. Kellogg Company. In this the major portion of the interface between the dissimilar metals is longitudinal to the pipe rather than transverse and therefore is subject principally to shear stress resulting from internal pressure or bending.

Control Rooms

Two control rooms, one for each pair of units, are located at the turbine operating floor level. They are T-shaped, as indicated on the plan view, with the electrical section forming the crossbar. Windows at the front give a view of the turbines and those at the rear look toward the boilers. The control rooms are air conditioned and soundproof and special attention has been given to the lighting to avoid glare and shadows. This objective was accomplished by employing indirect lighting together with a cove and arched-ceiling design. The various control panels are fitted with the usual indicating and recording instruments, automatic and manual control devices, alarms, and push-buttons for starting and stopping the equipment. Some of these are fitted in flow-line diagrams to assist the operator in visualizing the system.

The calculated net station heat rate at the best point is well under 10,000 Btu per kwhr for the first three units and about 9400 for the fourth unit which should better that of Units 2 and 3 by about 4 per cent, due to the employment of reheat.

The Electrical Engineering Department of the Public Service Electric and Gas Company was responsible for the mechanical and electrical design and United Engineers & Constructors, Inc., for construction. Design was started in January 1946, excavation one year later, and commercial operation of units Nos. 1 and 2 began on December 1, 1948, and November 30, 1948, respectively. The third unit was authorized in January 1947, and the fourth unit in December of that year.



Section through turbine-generator No. 1

Present and Future of Thermal Prime Movers

In an address before the Seventeenth Annual Convention of the Edison Electric Institute at Atlantic City, on June 1, the author discussed trends in central station practice, with specific reference to reheat, generator developments, topping units, steam-cycle limitations, gas turbines and fuels. An interesting set of curves illustrates technical progress in the utility field over the past forty years as concerns output, maximum demands, turbine and boiler sizes and available steam pressures and temperatures.

By C. W. E. CLARKE

Vice President and Consulting Engineer,
United Engineers & Constructors, Inc.

THERMAL prime mover development has been in process for the past several hundred years. By the start of the twentieth century reciprocating steam engines of 5000-kw capacity had been placed in service, but far greater power outputs were forthcoming from turbine improvements. Today one unit is operating in this country with a capacity of 200,000 kw, and there is the possibility of larger units being constructed should they prove desirable or necessary.

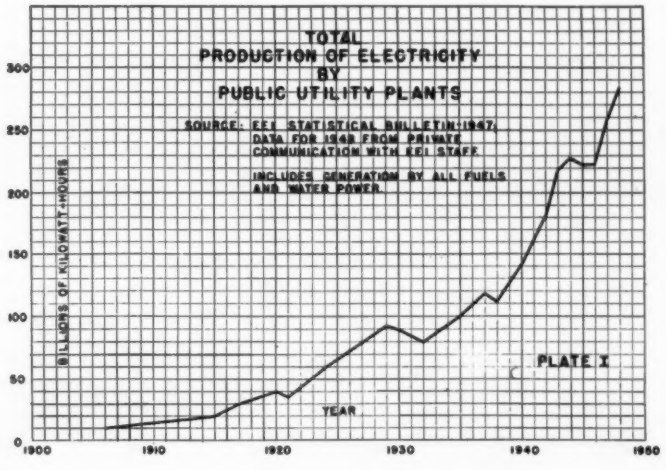
The accompanying charts show the production of electricity by public utility plants, maximum demands, available turbine sizes, steam pressures, steam temperatures, and boiler sizes for a period of about the last forty years.

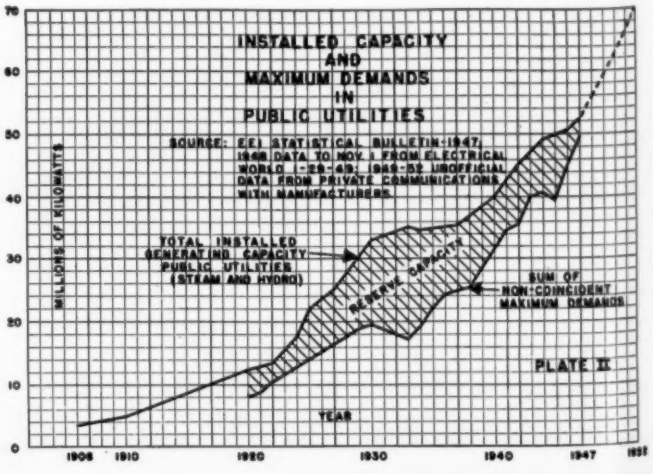
Reheat

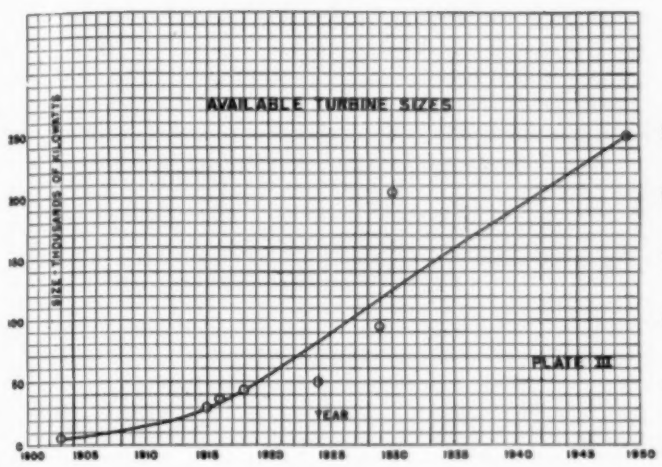
Up to about 1925, there had been a steady increase in unit sizes and also in the permissible pressures and temperatures at which they could operate. The maximum temperature limit for materials available for superheaters, piping and high-speed rotating units was between 700 F and 750 F. It was about this time that reheat appeared on the scene and reduced heat consumption of prime movers materially without increasing the initial temperature. Meanwhile, materials had shown a constant improvement with the consequence that, about 1934, steam temperatures started to increase. Allowable steam temperatures reached 950 F by 1938, making possible the achievement of the required economies without the complications attending reheat. At the present time throttle temperatures of 1000 F are coming into rather common usage with pressures of 1250 psig and higher, and a number of installations are under way to operate at 1050 F. For the moment this seems to be the maximum limit, and reheat is again in the picture.

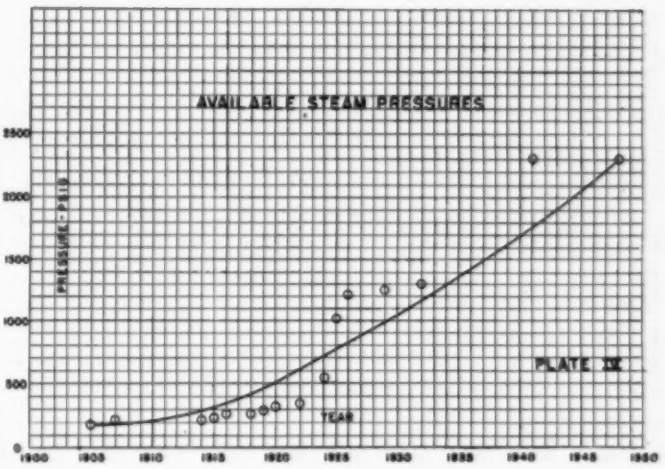
As an historical side line, it might be pointed out that reheat dates back at least as far as James Watt. In the course of his steam engine experiments, he took out a reheat patent covering steam-jacketing of cylinder walls to prevent condensation in the steam cylinder. Many of the large compound and triple-expansion steam engines installed in the late 1890's and early twentieth century had steam reheaters which reheated steam between the high- and low-pressure cylinders. In present-day practice the reheaters are actually secondary superheaters in the boiler, and temperatures are usually raised back to the initial temperature or very nearly so.

The case for or against the thermal advantages of reheat can be understood in the following example. Assuming the maximum desirable operating temperature to be 1050 F, a unit operating on a reheat cycle and




INSTALLED CAPACITY
AND
MAXIMUM DEMANDS
IN
PUBLIC UTILITIES
SOURCE: EEI STATISTICAL BULLETIN-1947, 1948 DATA TO NOV. 1 FROM ELECTRICAL WORLD 1-29-49; 1949-52 UNOFFICIAL DATA FROM PRIVATE COMMUNICATIONS WITH MANUFACTURERS
TOTAL INSTALLED GENERATING CAPACITY PUBLIC UTILITIES (STEAM AND HYDRO)
RESERVE CAPACITY
SUM OF NON-COINCIDENT MAXIMUM DEMANDS
MILLIONS OF KILOWATTS
YEAR
PLATE II





reheating back to 1000 F or 1050 F will produce economies comparable to those secured if the initial temperature were 1200 F without reheat. Developments are now in progress which may permit use of considerably higher temperatures and again make it inadvisable to consider reheat installations. Actual production of steam temperatures in the neighborhood of 1200 F presents a real problem to the boiler manufacturer; at such elevated temperatures somewhat different construction from that now customary would have to be adopted.

From the investment viewpoint the matter whether or not to use reheat must be settled for each case and depends somewhat on the size of the units involved, the cost of coal, and the type of load which can be assured the unit. For the larger-sized units, in the neighborhood of 100,000-kw capacity, the increased cost of a reheat over a nonreheat installation is of small magnitude. With units of half this size, the increased cost might amount to $10 or $12 per kilowatt.

Reheat turbines now on order total sixty units representing an aggregate capacity of about 3,500,000 kilowatts. This is nearly the same number and capacity as were installed in the previous wave of reheat installations.

Generator Developments

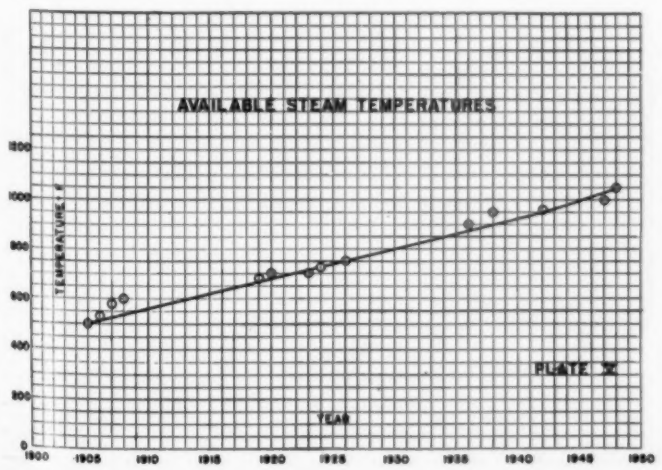
In 1937, the first hydrogen-cooled generator was placed in service, and today hydrogen cooling is universal in new units of 20,000-kw or larger capacity. Hydrogen pressures for generator cooling started out originally at $^1/_2$ psi, with the units frequently designed for operation at 15 psi to take care of differences in power factors and temperatures. Today machines are being designed for 30 psi and several are now operating, although not as yet at the maximum pressure. The kva gain between 15 psi and 30 psi is about 10 per cent. In southern sections where temperatures of cooling water are likely to be high, the increased hydrogen pressures have proved of inestimable advantage, and generator cooling should cease to be a problem.

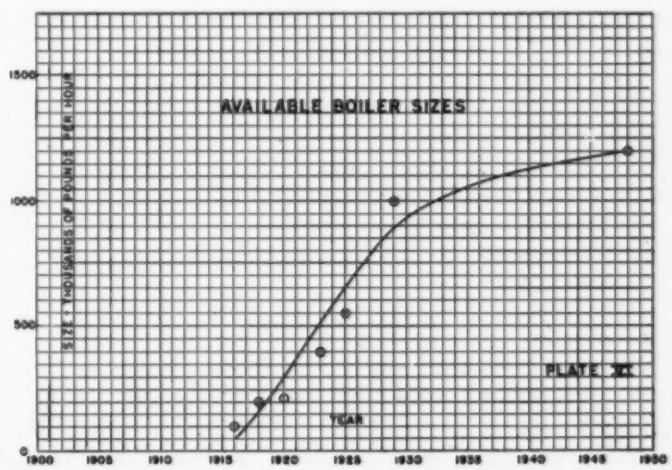
Topping Units

Topping units may be defined as consisting of a high-pressure turbine and boiler with the turbine exhausting at low pressure, say 200 psig to 300 psig, to the old low-pressure turbine-generator units. In the past twenty years a relatively large number of topping units has been placed in service to modernize older installations. They have made it possible to reduce the overall heat rate by 25 to 35 per cent and, in places where circulating water is limited, they have permitted an appreciable increase in generating capacity without placing further load on the circulating-water system.

Regenerative Feedwater-Heating Cycle

In the early 1920's, the regenerative feedwater-heating cycle came into use. By extracting steam from specific points in the turbine and utilizing it in feedwater





heaters through which condensate is passed, this cycle absorbs considerable latent heat which would otherwise be lost in the condensing water. It permits a saving from 12 to 15 per cent in energy.

Steam-Cycle Limitations

Steam cycles are subject to specific limitations as to obtainable efficiencies. The maximum steam pressure considered available for use in steam generating plants is approximately 2500 psig. At this pressure, with a multi-stage regenerative feedwater heating system, a temperature of 1050 F and 1000 F reheat, the net obtainable thermal efficiency would be between 36 and 38 per cent.

Stack losses and condenser losses affect overall performance. Present-day maximum boiler efficiency, keeping in mind cost of construction, is about 90 per cent, 10 per cent of the total energy in the fuel burned in the boiler being discharged into the atmosphere. Condenser losses, caused by the transfer of the latent heat in the condensed steam to the condensing water, amount to about 50 to 55 per cent of the total fuel burned.

The Gas Turbine

The gas turbine is actually a rather old idea. The principal difficulty encountered in its early design was the apparent impossibility of building a sufficiently efficient compressor. However, in recent years there have been intensive developments, particularly in Switzerland, where several manufacturers have built and have in operation gas turbines of considerable size, the largest one reported having a capacity of 27,000 kw. In this country in the power field there had been no comparable development up to the end of World War II. Recently, however, manufacture and usage of gas turbines have shown perceptible progress here, largely as a result of wartime development work in turbosuperchargers and jet engines for aviation use and parallel research in suitable metals for the high temperatures encountered in a gas turbine.

Outside of locomotive applications there are on order or in use seven gas turbines for utility company service: three 3500-kw units, three 5000-kw units and one 1875-hp unit.

The 3500-kw units are all of the simple, open-cycle type, which has a comparatively large heat loss in the exhaust. In some cases it will be economical for the heat in the exhaust gases to be transferred to a waste-heat boiler for production of low-pressure steam. At the Arthur S. Huey Station of the Oklahoma Gas & Electric Co., where the first of these three units is to be installed, the heat in the exhaust gases is being utilized for feedwater heating.

The three 5000-kw units are designed for closed-cycle, regenerative-type operation. The 1875-hp unit is to be used on a natural-gas line as a prime mover for operating a booster pump. All of the units mentioned are using either oil or gas as fuel.

One interesting thing about the gas turbine is the fact that thermal efficiencies can be obtained for a small unit far in excess of those obtainable from any comparably sized commercial installation employing a steam cycle. However, for the gas turbine to be fully acceptable to the utility industry at large, it will have to be constructed so that it can burn solid fuel. Research is being carried out in this direction, and progress is being made.

Among the large manufacturers active in gas-turbine development, one is working on a gas producer to provide gas from coal as a gas-turbine fuel. If it proves successful there would be no fly-ash involvement in the gas stream. Another approach to the fuel problem is that of burning fuel in a furnace and transferring the heat through heat exchangers to air under pressure and thence to the gas turbine. Under this arrangement no actual flue gas or fly ash enters the turbine.

Fuels—Future Trends

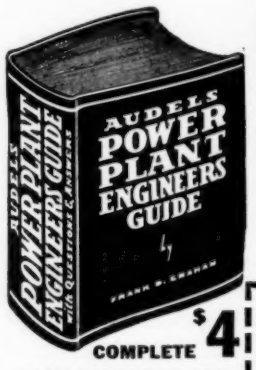
Wartime experience taught plant operators how to utilize many unfamiliar and inferior grades of coal; it also indicated the value of wise and conservative plant design. For the distant future it will be necessary to plan for the use of lower-rank coals, but for the immediate future there are ample reserves of relatively high-grade steam coals available to span the life of any installation being made at present.

The quality of coal from the important producing fields should steadily improve. Marginal wartime coal production is gradually being displaced in the market by production from modern, well-designed coal preparation plants. Improvement in coal quality will depend to a great extent on general business conditions and the ability of the coal industry to make the required investment in new mining equipment.

Conclusion

For units in the sizes generally required in the utility industry it is believed that the steam cycle will be the primary cycle for some time to come. An increased number of unit systems comprising one boiler and one turbine may be expected to be installed. There will also be a place for the gas turbine, considering that it can be built without requiring cooling water, can be remotely controlled and operated, and does not require complicated foundations or building structures. With all these advantages many utility systems should welcome the use of gas trubines even in moderate sizes.

In recent years the technical phases of the utility industry have been progressing at an ever accelerated rate. Advances in all branches of science point to and support the conclusion that even more developments may be expected in the future than in the past.



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Design and Operation of Spreader Stokers*

By WILLIAM S. MAJOR
Bituminous Coal Research, Inc.

A brief review of the development of this type of firing, together with a discussion of fuel adaptation, burning rates, carryover, cinder return, overfire air and combustion control.

INDIANA has been recorded as the birthplace of spreader-stoker firing in this country nearly 100 years ago. In 1857, James Hemington of Richmond was granted a patent on an apparatus for feeding fuel to furnaces by means of wings or blades. This principle, coupled with the ideas introduced by Stanley in England in 1822, has formed the basis for nearly all subsequent developments in spreader-stoker firing.

Many years elapsed, however, before spreader-stoker firing was accepted and extensively used as a reliable, efficient means of burning coals. Earlier stokers were provided with natural-draft grates having large air openings and operated with poorly applied regulation or none at all. They were mostly applied to older boiler furnaces with limited combustion space and short length of travel for flame and gases. As a result, cinder carryover and objectionable smoke emission were experienced and high furnace maintenance was sometimes encountered.

The advent of extensive development and use of spreader stokers in this country occurred approximately twenty-five years ago. During this period it has grown into one of the most popular types of stoker firing. Spreader stokers are now in service burning all grades of coal ranging from the lignites of 6700 Btu with 40 per cent moisture to the Eastern coals of 14,000 Btu. They have been extensively installed for the midwestern free-burning coals from Indiana and Illinois.

Two principles of feeding and distributing the fuel to the furnace and stoker grate are now used: (1) mechanical with "overthrow" or "underthrow" rotors, and (2) pneumatic feeding with nozzles. Fuel demands and operating conditions determine the number of rotors or nozzles required per furnace.

Spreader firing generally employs horizontal grates with small, closely spaced air openings that are supplied from forced-draft fans. For small and medium sizes of boiler furnaces, stationary and dumping types (either hand- or power-operated) are used. With these types of grates and multiple feeders, the air chamber is divided from front to rear so that there is an independent air supply and control for the grate section served by each feeder.

For higher steaming capacities, traveling grates that provide continuous ash discharge are being increasingly used. Drives for these grates are by motors through reduction gear boxes or electro-hydraulic drive. On some drives of the latter type a double-acting hydraulic cylinder actuates a ratchet and pawl mechanism connected to the sprocket shaft. Speed of the grate is varied by a flow-control valve that regulates the rate of oil flow to the cylinder.

Many factors must be considered in the design and operation of a spreader-stoker-fired steam generator in order to realize the highest order of acceptable performance. Although this stoker has proved its ability to burn a wide range of fuels, both as to kind and sizes, all furnaces have not exhibited equal versatility. Careful consideration and study must be given to the size, shape, and water-cooling of the furnace in the light of the characteristics of the fuels to be burned. Unless this is done, dependable performance is likely to be confined to a narrow range of coals in order to avoid such problems as excessive cinder carryover, fouling of boiler surfaces or higher furnace maintenance.

Operating experience, under a wide diversification of designed conditions, by spreader stoker and boiler manufacturers has revealed the essentials for a well-balanced and flexible operating unit. These requisites will be discussed starting with the coal at the stoker hopper.

Coal

The size consist should be well distributed between coarse and fine as delivered to the hoppers of all the feeders. If too large a portion of coarse coal is fed to one section of the grate, the fuel bed will not burn down evenly. This, in turn, may cause clinkers to form in the areas burning the larger sizes of fuel. An indication of proper coal sizing may be obtained from the manual "Industry Standards and Engineering Information" which is published by the American Boiler and Affiliated Industries. This manual recommends the following coal sizing specifications for spreader stokers:

Kind of Fuel	Sizing
Eastern bituminous (Friable)	1 1/4 in. nut and slack, not more than 50 per cent slack through 1/4-in. round mesh
Eastern bituminous (Non-Friable) and Mid-Western bituminous	3/4 in. nut and slack, not more than 50 per cent slack through 1/4-in. round mesh

* Presented May 10, 1949, to the Fuel Conference at Purdue University, Lafayette, Ind.

The above specifications should not be interpreted to mean that other sizes of fuels (particularly smaller sizes) cannot be burned on spreader stokers.

Grate Area and Furnace Volume

Stokers should be provided with sufficient grate area to maintain the burning rates within reasonable limits of the following specifications.

Type of Grate	Btu in Fuel per Hour per Square Foot of Grate area — Maximum Continuous	Peak for Two Hours
Stationary	400,000	450,000
Dumping	475,000	525,000
Traveling	575,000–700,000[1]	650,000–750,000[1]

The maximum burning rates shown for traveling grates are generally used only with steam generators of over 100,000 lb of steam per hour. Furthermore, these high rates are coupled with the use of large, completely water-cooled furnaces that have long flame and gas travel between grate and boiler entrance.

With refractory furnaces the heat liberation rate per cubic foot of volume should be kept under about 30,000 Btu per hr for maximum continuous duty and at not much over 35,000 Btu for peak demand. In the case of water-cooled furnaces, peak release rates of 40,000 Btu per cu ft may be used.

Carryover, Cinder and Fly Ash Return

Due to the principle of spreader firing, and the smaller sizes of coals that are burned, carryover in the combustion gases must be recognized. At higher burning rates and with the smallest sizes of coal the carryover is greatest. Most installations are now provided with systems for returning to the furnace the cinder that collects in the back hoppers of the boiler. In some cases the return of this cinder has increased efficiencies up to 5 per cent.

Because of increasing public demands for abatement of smoke and dust there is an increasing use of dust collectors. Although the low-resistance type will suffice for some furnaces, with relatively low burning rates and certain coal sizes, all jobs will not yield satisfactorily low dust emission with that type of collector. Then, too, municipal ordinances are becoming increasingly more stringent. At the present time permissible dust loadings range from 0.26 to 0.75 grains per cu ft, referred to gas conditions of 50 per cent excess air at 500 F, and the trend is definitely toward the lower loading.

The accompanying curves show collection efficiencies on the basis of particle size in microns, for typical high-resistance (*A*) and low-resistance (*B*) collectors. Using the size consist with 65 per cent of the dust larger than 44 microns (325 mesh), the collection efficiency of unit *A* is 93 per cent and 73 per cent for *B*. If the size consist with only 50 per cent of the particles larger than 44 microns is used, the resultant collection efficiencies become 91 per cent for *A* and only 65 per cent for *B*.

As a basis for comparing the performance curves of the two types of collectors, Fig. 1, a dust loading of 1.5 grains per cu ft (referred to 50 per cent excess air and 500 F) will be used. This loading has been employed by stoker and collector manufacturers as a guide in selecting fly-ash collectors for spreader firing. With this loading and the size consist of only 50 per cent larger than 44 microns, collector *A* will discharge to the atmosphere only 0.14 grain per cu ft. This performance not only meets the most stringent existing ordinances but also allows a margin of safety to meet higher dust loadings and less favorable size consist of dust that may be fed the collector. Collector *B*, however, when fed the same dust load and size consist will discharge 0.52 grain per cu ft. This emission is approximately twice the dust loading now specified in the proposed A.S.M.E. Dust Emission Code.

Return of the collector catch to the furnace remains open to discussion because of the questionable gain in efficiency and its influence on dust discharged to the

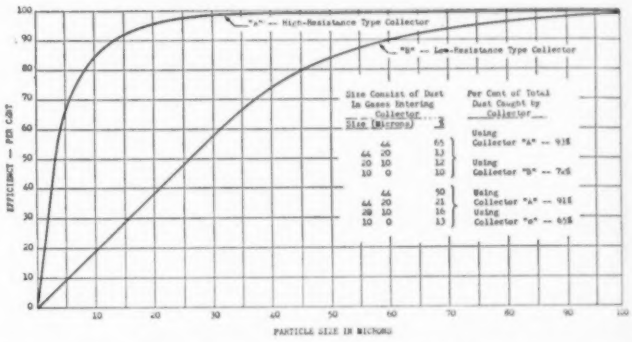

Fig. 1—Comparative performances of typical high-resistance and low-resistance collectors

atmosphere. In the study of the economic feasibility of return of the catch the fuel characteristics should be considered. Low-volatile coals have a higher carryover and a higher carbon content. High-voltage coals and lignites have a lower carryover with substantially lower combustible content. Table 1 shows data on this subject which was submitted during a Fuels Conference in Detroit on March 9.

TABLE 1

	Burning Rate, Btu/Sq Ft/Hr	Per cent Fuel Collected in Dust Collector	Per cent Combustible in Collector Refuse
Eastern low volatile	420,000	3.58	61.6
Eastern high volatile	405,000	1.75	46.1
Southern Illinois	438,000	3.61	37.1
Lignite	386,000	1.50	21.3

Furnace Turbulence and Overfire Air

Due to the thin, uniform fuel beds and low air pressures used under the grate, stratification of furnace gases is frequently encountered with spreader firing. It may be minimized through the use of overfire jets actuated by steam or fed by small-volume, high-pressure fans. On practically all newer installations steam jets and/or motor-driven fans capable of delivering 5 to 15 per cent overfire air at pressures up to approximately 30 in. w.g. are being built into the furnaces. They have proved effective in the improvement of combustion and in reducing cinder carryover. In 1944, Meissner and Funk reported that steam or air jets reduce cinder carryover and smoke, and increase boiler efficiency by as much as 1 to 3 per cent.

On some installations one fan is used to supply both overfire air and air for actuating the cinder return valves. With this type of system a branch duct diverts a portion of the air to the cinder return valve.

[1] Some authorities favor somewhat lower maximums—EDITOR.

At the present time there is still a wide diversification of opinion as to the most advantageous location of the overfire jets to promote maximum improvements in furnace performance.

Combustion Control

The characteristics of spreader-stoker firing with its thin fuel bed, small energy reserve in the furnace and sensitivity to variations in feeding rates necessitates the use of automatic combustion control, except when the boiler load is very steady. Even in such cases fuel economy will frequently justify the investment in some form of control.

With the positioning type control the "master," which is actuated by the steam pressure, adjusts the coal and air supply to meet load demands. A furnace-draft controller is used to adjust the uptake damper and maintain proper overfire draft.

The metering type of control employs a "master" to position the fuel feed and air flow controller mechanism to meet steam demands. The air flow controller then adjusts the forced-draft fan and furnace-draft controller that positions the uptake damper to restore equilibrium.

Ash Storage

Since excess air is drawn into the furnace when the ash-pit doors are opened for hopper cleaning, maximum ash storage space below the grates should be provided, because infrequent opening of the doors promotes more uniform furnace conditions and is conducive to better operating economy through lower average stack gas losses.

When installing spreader stokers for steam outputs of over 25 to 30,000 lb of steam per hour it is well to consider seriously the traveling grate machine. With this type continuous ash discharge is provided and the short periods of furnace disturbance that accompany grate cleaning with other types are eliminated. In some cases, continuous ash discharge coupled with adequate ash-hopper storage has been reported to have shown improvements in operating efficiencies up to 3 per cent.

Dependable, efficient performance of spreader-stoker-fired boilers, like any other type of firing, starts with the design of the unit. Although the spreader will burn a wider range of fuels and sizes more satisfactorily than any other type of stoker, this versatility is enjoyed only when the furnace is properly designed. Adequate furnace volume and cooling must be used to suit the fuel and load characteristics, if maximum economy and reliability are to be obtained. Then, too, efficient dust collectors are being increasingly used to provide acceptable performance.

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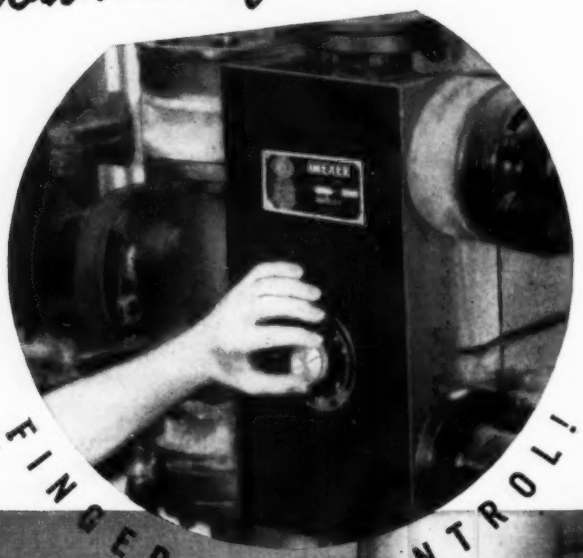

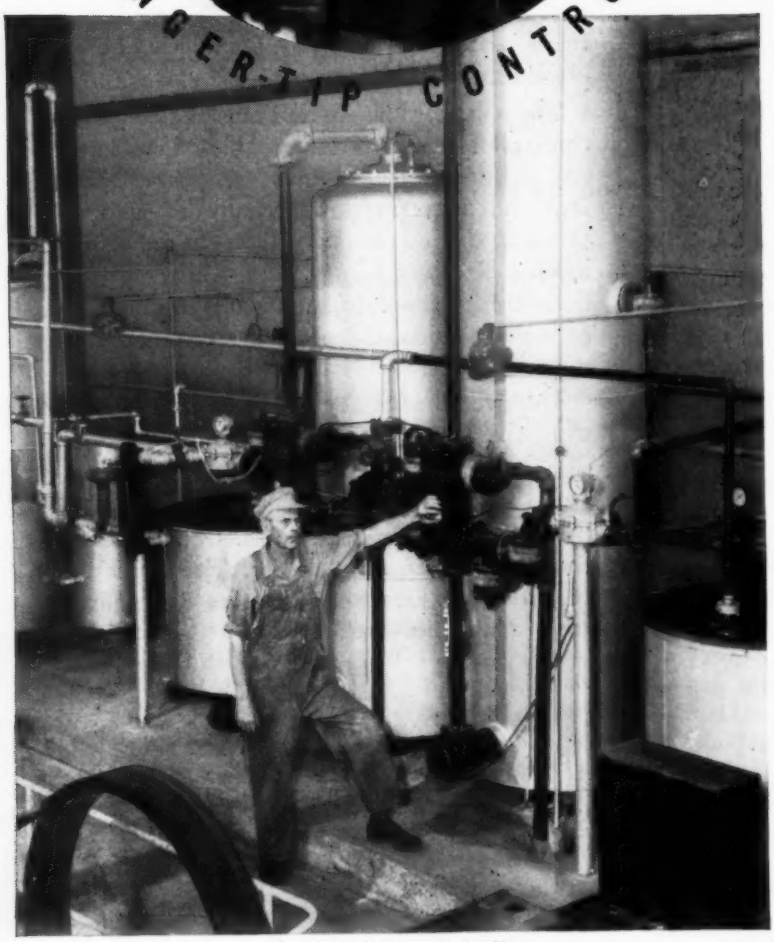

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Selection and Setting of Safety Valves for Power Boilers

By J. R. KRUSE

Chief Engineer, Chattanooga Division,
Combustion Engineering-Superheater, Inc.

Without attempting to enter into consideration of the many special problems and variables sometimes encountered, the author has attempted to clarify the more important points concerning which the average engineer may be confused. A number of typical examples are appended to assist in such understanding.

As a result of many comments received on the article, "Safety Valves for Stationary Power Boilers" that appeared in the March 1948 issue of COMBUSTION, this sequel is being written. In order to make this article complete it is of necessity that some repetition will be made of the previous article. This sequel will deal with the selection and setting of safety valves, not only for stationary boilers, but also for marine boilers.

General Definitions

1. SAFETY VALVE.—A valve that will automatically open at a predetermined pressure and relieve the excess pressure within the boiler drum and/or superheater header.

(*a*) A pilot-actuated safety valve is one which is operated from a pilot usually located on the drum.

(*b*) A power-control safety valve is one in which the disk is actuated by some mechanical or electrical means, and functions in relation to steam pressure.

(*c*) A duplex safety valve has twin disks, seats and springs mounted within a single body.

(*d*) An extra "working" safety valve is a somewhat recent term applied to a safety valve mounted on the superheater outlet, or the boiler drum, and having a stop valve between the safety valve and the source of the steam. The relieving capacity of such a valve is in addition to that specified by the Boiler Code. By having a stop valve ahead of the safety valve, a means is provided for removing it for repairs or replacement without shutting down the boiler.

2. DESIGN PRESSURE—That pressure referred to in the A.S.M.E. Boiler Construction Code, or similar Construction Rules or Codes, as the maximum allowable working pressure at which the boiler is permitted to be operated, based on the weakest part of entire unit.

3. OPERATING PRESSURE—(*a*) *At Drum.* This is usually a variable depending on the pressure drop through the superheater (if a superheater is included) which also varies with the evaporation rate at which the unit is operating.

(*b*) *At Superheater Outlet.* This is the desired pressure available at the outlet terminal of the superheater and is usually constant for all evaporation rates.

4. PRESSURE DROP—(For the purposes of this article.) That loss of pressure between the outlet of the boiler drum and the outlet on the superheater.

5. BLOWDOWN—Difference between pressure at which a safety valve opens and that at which it closes—usually expressed in per cent.

All pressures are in pounds per square inch gage.

"Code" Requirements for Safety Valves

The term "Code" can mean any of the construction or regulatory codes to which the unit is being made. For stationary or land boilers in the United States and many other countries, this Code will be the rules of the "Power Boiler Code" of the American Society of Mechanical Engineers. For marine boilers for the U. S. Merchant Marine there are two "Codes" usually to be followed, namely, "The U. S. Coast Guard Rules" (U.S.C.G.), and the American Bureau of Shipping Rules (A.B.S.). They are substantially alike. Frequently, especially for Canada or other foreign registry, Lloyds Rules (Lloyds Registry of Shipping) have to be met. The U. S. Navy has special requirements of its own. For the purpose of this article, the requirements of the A.S.M.E. Boiler Code will be used, pointing out some of the differences for marine rules where they occur.

Owing to frequent revisions of rules, it is necessary that a careful check be made in all cases to make certain the latest rules applicable are being followed.

Number of Valves Required

All power boilers having 500 sq ft or more of heating surface require at least two safety valves on the boiler drum and one on the superheater outlet header, when a superheater is included. An exception to this rule is sometimes found in Navy requirements, as is pointed out later in this article.

There has been some discussion between the engineers of the regulatory bodies as to permitting all of the safety valves to be placed on the superheater outlet. At this date, however, the author is not aware of any installations of this nature.

Capacity Requirements

Both land and marine boiler rules have two minimum requirements as to total steam-relieving capacities for calculating safety valves for water-tube boilers. The greater of these two values has to be met in both instances. One minimum is that the total combined safety-valve relieving capacity of drum and superheater valves shall be sufficient to relieve all of the steam which the unit can generate when operating at maximum capacity, so that pressure in the boiler will not increase to more than 6 per cent above the highest set safety valve and in no case more than 6 per cent above the maximum allowable pressure. This maximum rating of the boiler is that certified or specified by the boiler manufacturer.

The other minimum to be met is determined by the expression

$$E = H_1C_1 + H_2C_2$$

in which

E = total required relieving capacity of all the safety valves, in pounds per hour, which is 90 per cent of the tested capacity at the specified setting pressure as determined by the valve manufacturer in accordance with Code stipulations

H_1 = total heating surface of the boiler, including that of the tubes, drums and headers, exposed to the products of combustion

H_2 = total heating surface of waterwall tubes and headers, exposed to the products of combustion

The values of C_1 and C_2 vary with the general class of boiler and the method of firing, and are as follows:

	Water-Tube Boilers			Fire-Tube Boilers		
	Hand-Fired or Waste Heat	Stoker Fired	Oil, Gas or Pulverized Coal Fired	Hand-Fired or Waste Heat	Stoker Fired	Oil, Gas or Pulverized Coal Fired
C_1	6	8	10	5	7	8
C_2	8	12	16	8	10	14

For E in the above expression, the 90 per cent of tested capacity is an A.S.M.E. requirement. U.S.C.G. and A.B.S. Rules permit a full 100 per cent of tested capacity rating to be used.

In the case of fire-tube boilers, there are certain size openings for the mountings for safety valve inlet that are also required. The A.S.M.E. Boiler Code gives these requirements in Par. P-278 and Table P-14. The requirement is somewhat of a safeguard against the possibility of attaching very low capacity safety valves on relatively small openings intended for high capacity safety valves.

Safety Valve Mountings

The general rule is to have each safety valve on a separate nozzle or mounting. Variations permissible, however, are to have two valves on a Y-base or to use a duplex valve. The latter is quite common in marine practice.

When mounted separately, and only two valves are on a drum, one valve may have a capacity of not less than one-half of the other valve. If mounted on a Y-base, or if of duplex construction, then both valves must be of the same relieving capacity for a given setting. They may be set at different pressures, however. If more than two safety valves are required, there are no requirements as to relative capacities.

No steam outlet connection other than for a safety valve is permitted on any required safety valve nozzle, except for a soot blower which can be attached to the safety valve connection of the superheater only.

The maximum distance between the inlet flange of a safety valve and the flange of a nozzle to which it is attached cannot exceed the face-to-face dimension of a standard T-fitting (A.S.A. Std.) for the required size and pressure. All safety valves must be attached so as to have their stems in the vertical position.

Locations

Boilers without superheaters, or if there is an intervening stop valve between the steam drum and the superheater, require a sufficient number and capacity of safety valves mounted on the drum for 100 per cent of the required relieving capacity. Boilers with superheater and no intervening stop valves, according to A.S.M.E., U.S.C.G. and A.B.S. Rules, must have not less than 75 per cent of the required capacity on the drum. The remaining 25 per cent can be on the superheater outlet, ahead of the stop valve. Navy practice provides that not less than 25 per cent can be taken on the superheater.

All of the above-mentioned rules require at least one safety valve on the superheater outlet, but none specifies any minimum relieving capacity for the superheater outlet location. For adequate protection of the superheater, some manufacturers place a minimum of 20 per cent of the actual required total capacity on the superheater outlet header. This is based on actual evaporation and not on Code requirements of total capacity, which in some cases is greater than actual maximum evaporation capacity.

Selection of Safety Valve Setting Pressures and Capacities

There are many hhases to consider in addition to Code rules when it comes to the selection of the proper size or capacity of the valve; also for the proper pressures at which all valves are to be set to relieve. Consideration must be given to the relieving capacity with respect to evaporative capacity of the boiler. For example, a single safety valve may have sufficient capacity to upset the water level within the steam drum. Having many valves of small capacity is not economical.

The Codes do not require that all of the valves be set at different pressures. If all were set at one pressure (which is permitted by most Codes) then the effect would be the same as having a single valve of too much capacity, and an upset water level may result. Some Codes do not require that the safety valve on the superheater be set at a lower pressure than the setting of the valves on the drum. If not properly set, this could cause the overheating of the superheater under certain conditions.

There is a difference of opinion among operating engineers and among some of the safety-valve manufacturers as to whether the saturated valves (on drum) or the superheater valve should bear the wear and tear of being the first valve to relieve. Some are of the opinion that the safety valve on the drum operating only on saturated steam has a better chance to withstand the shock or punishment of frequent "popping" than the

safety valve operating at the high temperature of superheated steam. They believe that a safety valve operating on saturated steam will repeatedly open and close at the set pressures more consistently than will the superheater safety valve. Others are of the opinion that the modern superheater safety valve is of such materials and workmanship as to withstand the required service, operating on either saturated or superheated steam.

In many cases, settings of superheater and drum valves have been such as to cause the superheater safety valve to open first for the lower ratings, say up to 40 or 50 per cent of maximum rating, and above this rating the drum valve will relieve first. This assures ample protection to the superheater by always providing sufficient steam flow through it.

Some engineers, however, prefer that the safety valve on the superheater relieve first under all circumstances. In some cases this may require a unit to be of higher design pressure, in order to maintain a given minimum operating pressure at the superheater outlet, where the pressure drop through the superheater is relatively high. This higher design pressure means greater first cost.

The subject of capacities and relieving pressure settings can best be discussed simultaneously. In discussing capacities, it is well to point out here that those of power control safety valves or "extra working" safety valves cannot be included in the *required* capacities. These types of valves have a stop valve between the inlet and steam source and, therefore, cannot be considered as a 100 per cent safety device.

It is sometimes desirable to have two "extra working" valves of each size and setting. One is mounted on a straightway stop valve on each steam generator and the other is a spare that can quickly replace the "extra working valve" that may need repairing. Having the stop valve under this safety valve permits replacement without necessity of shutting down the unit. This feature may occasionally avoid an unscheduled shutdown. The second extra working valve is not always necessary since usually the valve on the unit can be removed, repaired and reinstalled without shutting down, and the required safety valve protection is available on the unit although those valves are set to relieve at a slightly higher pressure.

As to Code requirements for the setting pressures at which all safety valves are to be set there is very little difference between the various Codes. For simplicity, A.S.M.E. requirements only will be considered here. Code requirements are for assurance of safety and are, therefore, mostly relative to design pressure, and range of settings. The Code requires that the highest set safety valve on a boiler shall be at a pressure not greater than 3 per cent above the maximum allowable (design) pressure of the entire steam generating unit. The range between the lowest set valve and the highest set valve shall be not more than 10 per cent of the pressure of the highest set valve. The setting pressure of the lowest set valve shall not be greater than the design pressure of the unit. Since, as pointed out under the heading "Capacity," the pressure cannot be permitted to increase more than 6 per cent above the design pressure, the range of pressure settings is limited to less than 10 per cent when the lowest set valve is set at design pressure. Safety valves may be set at any desired pressure up to and including the design pressure for the lowest set valves and within the limitations given above. Those are the rather simple Code requirements.

For better performance, however, greater consideration is given by the boiler manufacturer to the question of the settings of all safety valves on the boiler and superheater. It is common practice always to set the safety valve on the superheater to relieve at a pressure sufficiently lower than that of those on the drum, so as to assure adequate protection of the superheater under all conditions. This differential setting between valves on drums and those on superheaters varies from 2 to 3 lb on small low-pressure boilers to as much as approximately 100 lb on large high-pressure units. This depends on the amount of pressure drop through the superheater and also on the operating engineer's preference with regard to whether he wants the superheater safety valve to open first under all conditions, or just to make certain the superheater is protected by having ample steam flow through it at all times.

It is desirable to have a margin of at least 3 or $3^1/_2$ per cent between the setting of the lowest set safety valve and the desired operating pressure. This is to insure positive seating of the safety valve.

The per cent of "blowdown" of all safety valves has to be considered in order to determine the additional pressure required above the desired minimum operating pressure. This additional pressure sets the required design pressure. For example, assume a unit with a required minimum pressure at the superheater outlet of 750 psi. At maximum rating this unit will have a pressure drop through the superheater of 50 lb. Therefore, the minimum operating pressure in the drum must be 750 + 50 = 800 psi. Based on a 3 per cent blowdown of the drum safety valve, the minimum design pressure would be 825 psi (3 per cent of 825 = 24.75).

In this case the lowest set safety valve on the drum would have to be at design pressure, namely, 825 psi, and the highest set valve would have to be not more than 3 per cent above design, or 850 psi. (A 3 per cent increase in setting pressure is about the maximum that can be had, so as not to have an actual increase in pressure of more than the 6 per cent permitted by the Code. That is the characteristic of most safety valves.) The highest set valve on the drum may be any setting between 825 and 850 psi. To insure 750 psi at the superheater outlet, the safety valve on the superheater must be set at approximately 3 per cent above 750 psi, or at about 773 psi, as the minimum setting. The superheater safety valve *may* be set at any setting between 773 and about 10 lb less than the lowest set valve on the drum which would be 815 psi. (This 10-lb differential is a recommended value and not a Code requirement and would, as a rule, be sufficient for adequate protection of the superheater in this particular case.)

Occasionally "border line" cases may be responsible for certain settings within the range of the choice of settings. That is, maximum settings are sometimes used in order to obtain the maximum capacities that may be required to meet the Code. It is common practice to interpret the Code in that only the capacity of each valve, at its particular setting can be used in figuring the total capacity of all valves. For example: A boiler drum may be fitted with four 4-in. safety valves with settings ranging from 1000 to 1030 psi and with a total capacity based

on those settings aggregating 544,200 lb per hr (ranging from 134,000 to 138,000 for each valve). Suppose the requirements total 550,000 lb per hr capacity on the drum. The above does not quite meet that requirement. However, if all valves are "blowing," then they actually are relieving steam at a pressure equal to or above the setting pressure of the highest set valve, namely at 1030 psi, and at practically the rated capacity of the highest set valve. This would give an actual total capacity of 4 × 138,000 = 552,000 lb per hr which would satisfy Code requirements. Enforcement authorities, however, do not always concur with this interpretation of the Code.

When safety valves of different sizes or capacities are mounted on one unit, it is customary to set the lowest capacity valve at the lowest setting. Frequently, this may prevent upsetting the water level of the steam and water drum. This is especially true when the unit requires only two valves on the drum.

Another so-called "border line" item is in regard to the temperature-pressure ratings as given in the Code for steel flanges and flanged fittings. Such ratings are not applicable to safety valves. This is not a Code limitation, but rather a limitation of the safety valve manufacturers. Since safety-valve springs, bodies and other parts are affected by temperature, the safety-valve manufacturers set specific pressure and temperature limitations on their safety valves that do not agree with the temperature-pressure ratings as given by the A.S.M.E. Code and American Standards Association Standard B16-e—"Steel Flanges and Flanged Fittings."

Per Cent of Blowdown

As to the per cent of blowdown of a safety valve, it is customary to use not less than 3 per cent for standard safety valves, either for the actual per cent of blowdown, or for the margin in pressure between the safety-valve setting and the actual operating pressure. For that reason, it is common practice, especially on large utility type boilers, to use an extra safety valve, either of the electrically controlled type, or of the pilot-actuated type. These valves can be set so as to have as little as 1 per cent blowdown and also operate the boiler at a pressure within 1 per cent of the safety-valve setting pressure. Such valves are mounted on a valved connection so the valve can be removed for repairing without necessity of shutting down the unit. Such valves, therefore, cannot be included in the relieving capacities required by the Code.

There are also standard safety valves now on the market for which settings of as little as 1 per cent blowdown are claimed. It is understood, however, that the relieving capacity is somewhat reduced when so set, compared with a setting for the usual 3 per cent blowdown. Furthermore, it is understood that the manufacturers recommend the usual 3 per cent between operating and safety valve setting pressures.

Before actually selecting safety valves and specifying the actual sizes, capacities and settings, the particular Code under which such equipment is to be made and operated should be carefully studied.

EXAMPLES

The following examples are typical for the various types of boilers and to meet the various Code requirements. Due to frequent revisions of safety valve capacities by the manufacturers, the values used may not be those of any particular manufacturer, but will serve to illustrate methods of selecting safety valves and provide a clearer understanding of the subject.

Example No. 1

(*a*) A hand-fired water-tube boiler having 2500 sq ft heating surface, manufacturer's rating of 15,000 lb per hr, design pressure 200 psi (no water walls—no superheater), operating pressure 125 psi. Boiler operated as a stationary (land) unit.

Required safety valve capacity: Based on manufacturer's rating = 15,000 lb per hr. Based on Code heating surface formula = 2500 × 6 = 15,000 lb per hr. Here Code and manufacturer's ratings are the same. For minimum operating pressure of 125 psi lowest setting of the safety valve can be about 3 per cent above 125, or 129 psi. (As for the boiler of 200 psi design pressure, the lowest set safety valve can be anywhere between 129 and 200 psi.)

One $2^1/_2$-in. valve set at 130 psi = 8,620 lb per hr (close at 126 psi)
One $2^1/_2$-in. valve set at 135 psi = 8,920 lb per hr (close at 131 psi)

Total = 17,540 lb per hr

(*b*) Assume a fire-tube boiler of the same design pressure (200 psi), the same heating surface (2500 sq ft) and same desired operating pressure (125 psi), as in (*a*), but here manufacturer's rating is only 10,000 lb per hr. For a fire-tube boiler the Code requires only 5 lb per sq ft of heating surface, therefore, Code requirements = 2500 × 5 = 12,500 lb per hr, which is greater than the manufacturer's rating of 10,000 lb per hr.

One 2-in. valve set at 130 psi = 5,240 lb per hr (close at 126 psi)
One $2^1/_2$-in. valve set at 135 psi = 8,920 lb per hr (close at 131 psi)

Total = 14,160 lb per hr which meets

all requirements as to capacity, but for a fire-tube boiler the Code requires also a certain area of safety valve connections, which in this case equals a total of 12.706 sq in. The nearest nominal sizes would be two 3-in. diameter connections totaling 14.12 sq in. Therefore, it would require two safety valves, each having 3-in. diameter inlets. A low capacity safety valve could then be used.

One 3-in. set at 130 psi = 5,240 lb per hr
One 4-in. set at 135 psi = 8,620 lb per hr

Total = 13,860 lb per hr

(*c*) Assume same as for (*a*), but this time for U.S.C.G. (marine service). Here the capacity requirements are the same as for A.S.M.E., but for marine service the full 100 per cent of tested capacities may be used, instead of 90 per cent as required by A.S.M.E. These increased capacities, therefore, permit the use of one smaller valve, or

One 2-in. valve set at 130 psi = 5,830 lb per hr
One $2^1/_2$-in. valve set at 135 psi = 9,900 lb per hr

Total = 15,730 lb per hr

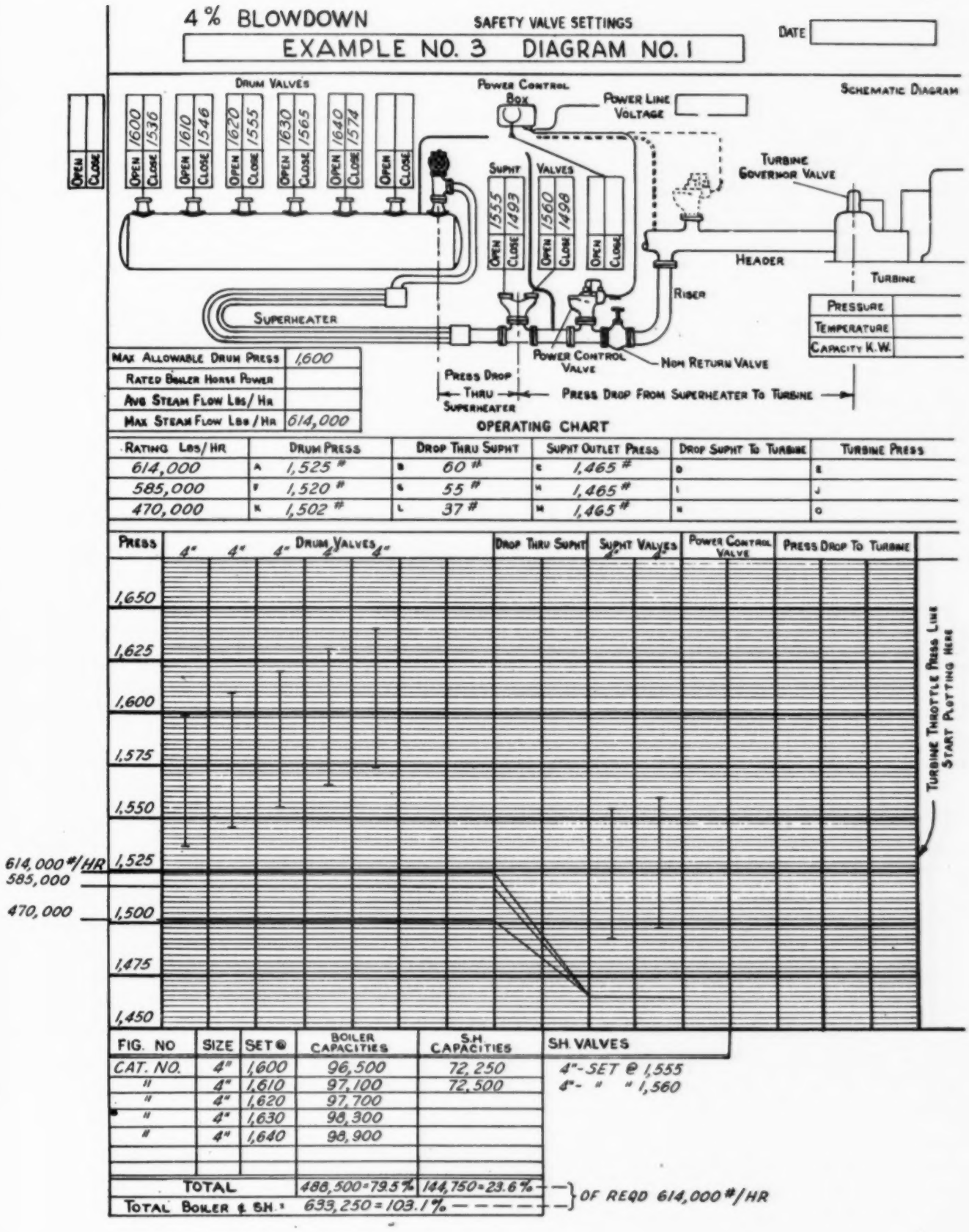
(*d*) Assume same as (*a*) but add water-wall surface of 300 sq ft and a 100 deg F superheater—A.S.M.E. requirements. Manufacturer's rating = 15,000 lb per hr. Code requirements = (2500 × 6) + (300 × 8) = 17,400 lb per hr. A minimum of 75 per cent of 17,400 = 13,050 can be on boiler (balance on superheater). A minimum of 20 per cent of 15,000 = 3000 is manufacturer's recommendation for superheater The maximum of 17,400 − 13,050 = 4350 on the superheater can be used in calculating safety valve requirements. For the boiler drum,

One 2-in. set at 135 psi = 5,344 lb per hr
One $2^1/_2$-in. set at 135 psi = 8,920 lb per hr

Total = 14,264 lb per hr

plus one 2-in. set at 129 psi = 4,990 (corrected for 100 deg F superheater)

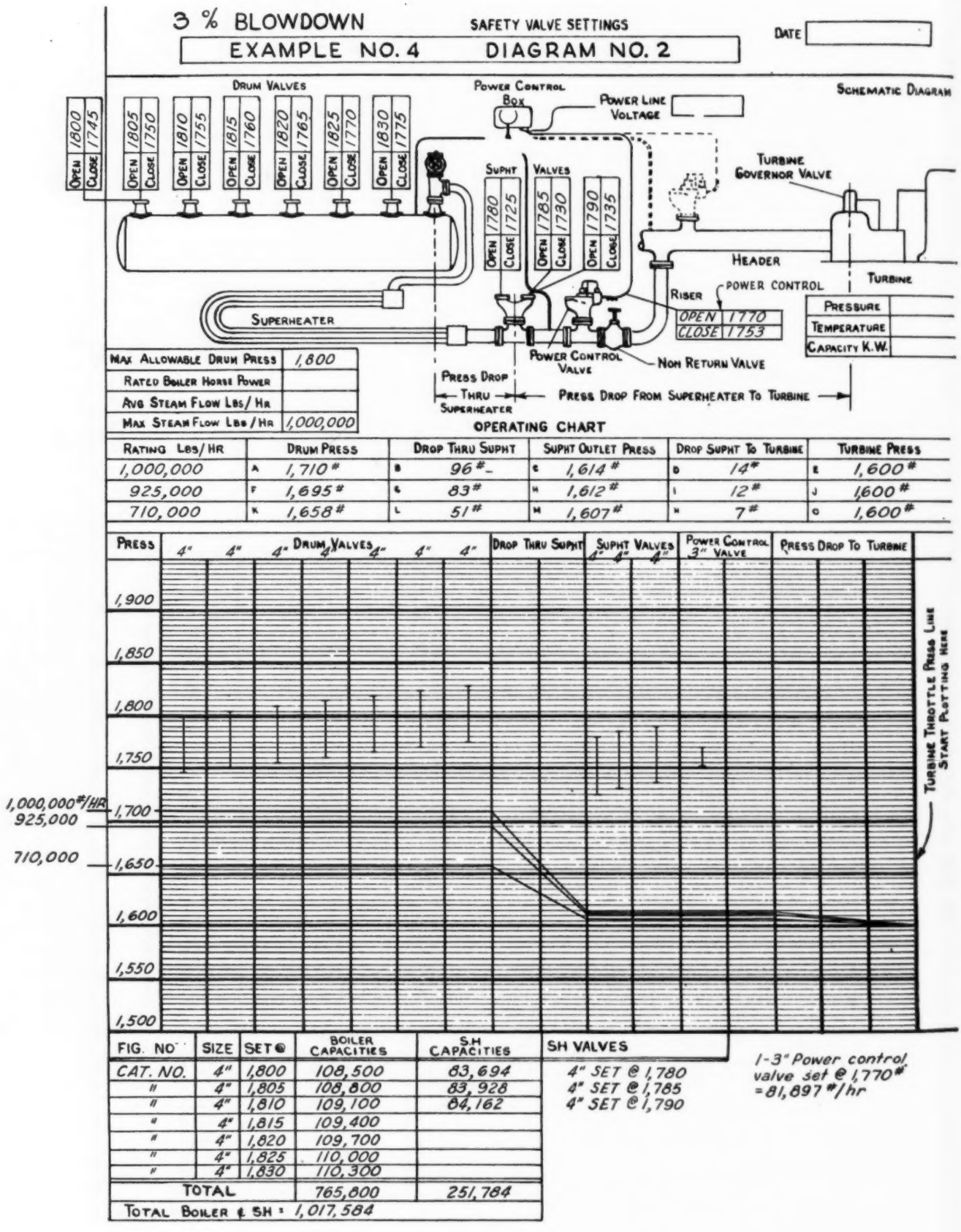
Grand total = 19,254 lb per hr, which satisfies all requirements.



Rating Lbs/Hr	Drum Press	Drop Thru Supht	Supht Outlet Press	Drop Supht To Turbine	Turbine Press
614,000	A 1,525 #	B 60 #	C 1,465 #	D	E
585,000	F 1,520 #	G 55 #	H 1,465 #	I	J
470,000	K 1,502 #	L 37 #	M 1,465 #	N	O

Press	Drum Valves	Drop Thru Supht	Supht Valves	Power Control Valve	Press Drop To Turbine
1,650	4" 4" 4" 4" 4"		4"		
1,625					
1,600					
1,575					
1,550					
1,525					
1,500					
1,475					
1,450					

Fig. No	Size	Set @	Boiler Capacities	S.H. Capacities	S.H. Valves
Cat. No.	4"	1,600	96,500	72,250	4"-Set @ 1,555
"	4"	1,610	97,100	72,500	4"- " " 1,560
"	4"	1,620	97,700		
"	4"	1,630	98,300		
"	4"	1,640	98,900		
TOTAL			488,500 = 79.5%	144,750 = 23.6%	} of Reqd 614,000 #/Hr
Total Boiler & S.H.			633,250 = 103.1%		} of Reqd 614,000 #/Hr



OPERATING CHART

RATING LBS/HR	DRUM PRESS	DROP THRU SUPHT	SUPHT OUTLET PRESS	DROP SUPHT TO TURBINE	TURBINE PRESS
1,000,000	A 1,710#	B 96#	C 1,614#	D 14#	E 1,600#
925,000	F 1,695#	G 83#	H 1,612#	I 12#	J 1,600#
710,000	K 1,658#	L 51#	M 1,607#	N 7#	O 1,600#

FIG. NO	SIZE	SET @	BOILER CAPACITIES	SH CAPACITIES
CAT. NO.	4"	1,800	108,500	83,694
"	4"	1,805	108,800	83,928
"	4"	1,810	109,100	84,162
"	4"	1,815	109,400	
"	4"	1,820	109,700	
"	4"	1,825	110,000	
"	4"	1,830	110,300	
TOTAL			765,800	251,784
TOTAL BOILER & SH = 1,017,584				

SH VALVES
4" SET @ 1,780
4" SET @ 1,785
4" SET @ 1,790

1-3" Power control valve set @ 1,770#
=81,897 #/hr

Similar variations in capacity requirements and actual capacities have to be accounted for when figuring such a unit for marine practice.

In accordance with the capacity formula, a greater safety valve relieving capacity would have to be provided if any of the above examples were either stoker, oil or pulverized fuel fired, although the manufacturer's rating might remain the same.

The foregoing examples serve to show the many variations for units having so near the same ratings, pressures, etc. The following examples are for water-tube boilers, water walls and superheaters based on A.S.M.E. Code rules.

Example No. 2

Maximum rated capacity = 300,000 lb per hr, design pressure = 900 psi, boiler heating surface = 14,665 sq ft, water-wall heating surface = 3084 sq ft. Fuel is pulverized coal. Total temperature 950 F. Pressure drop through superheater = 35 lb maximum. Required minimum operating pressure at superheater outlet = 830 psi.

Safety valve capacity required to meet manufacturer's rating:

Boiler, 225,000 lb per hr min.
Superheater, 75,000 lb per hr max.
Superheater, 60,000 lb per hr min.

Safety valve capacity required to meet Code requirements:

Boiler heating surface = 14,665 × 10 = 146,650 lb per hr
Water-wall heating surface = 3,084 × 16 = 49,344 lb per hr

Total = 195,994 lb per hr

From the above, it can be seen that the safety valve relieving capacity based on manufacturer's rating is considerably above that of the Code formula based on heating surfaces.

For this case there will be a choice in the settings of safety valves within the following range. Minimum setting of safety valve on the superheater outlet will be about 3 per cent above minimum operating pressure, or 830 + 25 = 855 psi. The minimum set safety valve on the drum will be minimum superheater outlet pressure (830 psi) plus pressure drop through superheater (35 lb) plus about 3 per cent of (830 + 35) = 881 lb. The maximum setting of lowest set safety valve on the drum will be design pressure of 900 psi. The maximum recommended setting of the safety valve on the superheater will be not less than 5 lb under the lowest set drum valve. (Some engineers prefer a minimum of 10 lb).

Based on the minimum setting pressures for all valves, an economical selection would be:

One 3-in. valve set at 881 psi = 118,330 lb per hr
One 3-in. valve set at 895 psi = 118,850 lb per hr

Total on drum = 237,180 lb per hr

On the superheater and corrected for 950 F.
One 3-in. valve set at 855 psi = 114,850 lb per hr
Total drum and superheater capacity = 352,030 lb per hr

By going to the highest settings permitted, a saving can be made, if preferred, by reducing the size of the superheater safety valve. This would require valves as follows:
On the drum

One 3-in. valve set at 900 psi = 120,800 lb per hr
One 3-in. valve set at 920 psi = 123,500 lb per hr

Total capacity on drum = 244,300 lb per hr

On the superheater

One $2^1/_2$-in. valve set at 895 psi = 60,000 lb per hr

Total on drum and superheater = 305,300 lb per hr

In this particular illustration, the very minimum capacity in the superheater is used, which may not be desirable.

Example No. 3

In selecting safety valves for very high-capacity boilers, a diagrammatic form is generally used to show more clearly the entire "Safety Valve Story" somewhat graphically. Several forms of these diagrams are used and a typical one is used for this example No. 3 and is labeled Diagram No. 1. This example is based on pulverized fuel firing of a radiant type boiler, having no boiler heating surface, but a water-wall surface of 13,765 sq ft. It is obvious that the manufacturer's rating of 614,000 lb per hr is much higher than the Code formula requirements based on heating surface which is 13,765 × 16 = 220,240 lb per hr. The latter is, therefore, disregarded.

It will be noted that this example does not include a power control valve. It will also be noted that the differential between the lowest set safety valve on the superheater and that on the drum is 45 lb. This means that at all ratings up to that at which there is 45 lb or more pressure drop through the superheater (which will be at about 500,000 lb per hr) the safety valve on the superheater will open first. At all ratings above this point, the low set valve on the drum will open first.

In this example, the pressure at the superheater outlet is held constant for all ratings, namely, 1465 psi.

Example No. 4

Another case using a diagram is shown as Diagram No. 2. This is for a 1,000,000-lb per hr steam generator for 1800 psi design pressure. As is the case in practically all of the very large steam generators, the safety valve capacity requirements based on the Code heating surface formula can be disregarded, since the manufacturer's rated capacity is always much higher. In this example, the superheater outlet pressure varies slightly with rating and the turbine throttle pressure is constant, namely, 1600 psi. Here, again, it will be noted the differential between the lowest set safety valve on superheater and on drum is only 20 lb. Therefore, at all ratings up to and including that where there is a 20-lb pressure drop through the superheater (probably around 500,000 lb per hr) the safety valve on the superheater will open first. For all ratings where the pressure drop through the superheater exceeds 20 lb, the lowest safety valve on the drum will open first.

This 20-lb differential of safety valve settings between drum and superheater provides for ample flow of steam through the superheater at all load conditions, so as to prevent any appreciable overheating of the superheater elements.

Other Cases

There are many other examples that could be given to show the wide variations that have to be considered when selecting safety valves and specifying the setting pressures. These include borderline cases in regard to pressure, capacity and temperatures, which have already been mentioned.

A case that occasionally comes up is that of a high-pressure steam generator which is to be operated temporarily at relatively low pressure, and must be provided with the necessary safety valves to protect existing steam-consuming equipment against the higher pressure. In such a case, it is usually found most economical first to select the required safety valves for the future high-pressure conditions. These valves will first be fitted with the lower pressure springs that will suit the temporary low-pressure condition, and later be fitted with the standard high-pressure springs when the change to high-pressure operation is made.

Obviously, these high-pressure valves will have a corresponding lower capacity rating for the lower operating pressure condition and will have to be supplemented by additional safety valves. Usually these supplementary valves are rather large and of only the necessary design pressure to suit the lower pressure requirements. Extra nozzles have to be provided to fit these safety valves to drums (and superheater, if required). Such nozzles have to be suitable also for the high-pressure condition and are fitted with blind flanges when the change to high-pressure operation is made.

It is not uncommon to have the temporary low-pressure valves made with high-pressure series flanges, so as to fit the necessary high-pressure series nozzles on the boiler; that is, the low-pressure safety valve may be a 400-lb series, but with a 900-lb series inlet flange.

The author realizes that there are many variables and other items that have not been mentioned, which have to be considered in the selection of safety valves and in specifying their relieving pressure settings. It is hoped, however, that this article will serve to clarify some of the phases of this subject, about which there has been considerable confusion in the minds of some of the operating men as well as some design engineers.

A.S.M.E. Semi-Annual Meeting at San Francisco

SAN FRANCISCO played host to the A.S.M.E. Semi-Annual Meeting which was held in the University of California Extension Building from June 27 to July 1. Technical sessions were held in the mornings, while afternoons were given over to inspection trips to such places as the San Francisco Naval Shipyard, University of California cyclotron, Ames Aeronautical Laboratory and Station "P" of Pacific Gas & Electric Co. The banquet on Wednesday evening featured presentation of awards by **James M. Todd,** president of A.S.M.E., and an address by **Robert G. Sproul,** president of the University of California. On Thursday evening a dinner was held in honor of **William F. Durand,** past president of A.S.M.E. and professor emeritus of mechanical engineering at Stanford University.

In the 27 technical sessions more than 60 papers were presented on a wide variety of mechanical engineering subjects. There were five papers in the gas turbine field, relating primarily to aeronautical applications. In addition to the papers in the steam power field reported here, **F. P. Fairchild** spoke on "The Design of Sewaren Generating Station and No. 1 Unit at Essex Station of Public Service Electric & Gas Co.," and **H. E. White,** of Stone & Webster Engineering Corp., presented a summary of four papers on marine fouling originally given at the Spring Meeting in New London.

Steam Power Expansion in California

Steam power facilities are being expanded so rapidly in California that by 1951 almost half the state's power will be steam generated, according to papers presented by **C. C. Whelchel** and **W. R. Johnson** of the Pacific Gas and Electric Company and **W. L. Chadwick** of the Southern California Edison Company, who gave several reasons for the current emphasis on steam power.

A population increase of 47 per cent in Southern California and 51 per cent in Northern California since 1940 has made necessary the provision of additional power facilities. Since the more favorable water power sites within economical transmission distance of cities already are developed, the logical alternative was to concentrate on development of steam generated power. Technological improvements in steam plant design, such as larger unit size and higher efficiency, have tended to reduce the relative cost of steam generated power, although high fuel costs have partially offset these savings. The overall result of all these factors, however, has been a gradual shifting of the economic steam-hydro ratio from 75 and 66 per cent hydroelectric in Northern and Southern California, respectively, to nearly equal amounts of steam and hydro in each.

The postwar expansion programs are expected to add 1,747,000 kw to the state's steam power capacity by 1951. Of this amount 987,000 kw will be added to the power capacity of Northern California and 760,000 kw to Southern California.

Steam power expansion in Southern California is being undertaken by the eight power systems serving the area, according to Mr. Chadwick. These include the Los Angeles Municipal Department of Water and Power, the municipally owned systems of the cities of Pasadena, Glendale and Burbank, the Imperial Irrigation District, the San Diego Gas and Electric Company, the California Electric Power Company and the Southern California Edison Company.

The Southern California expansion has been noteworthy for several developments besides the rapid change in the steam-hydro ratio. For example, natural gas and oil have been used exclusively as fuel for producing steam power, although provisions have been made at the plants to permit future use of coal. A large increase in fuel oil stocks during the last few months seems to have halted further increases in oil prices, however, and backed off any immediate necessity for seriously considering coal for fuel.

Steam power developments in Southern California have been kept in the moderate pressure and temperature range and outdoor-type plants have been used. Burbank and Glendale were the first to make use of outdoor plant designs, followed by the Southern California Edison Company which used a similar design for its new Redondo Station with outdoor boilers, air preheaters, fans and oil heaters. Further use of this principle in the near future seems certain. There also has been extensive use of special operating methods, controls and construction to obtain minimum time–load pickup. The Redondo Station, for example, is designed to increase from five per cent to full load in fifteen seconds.

The steam power expansion program in Northern California is being undertaken principally by the Pacific Gas and Electric Company and to a lesser extent by the United States Bureau of Reclamation, according to Mr. Whelchel and Mr. Johnson. The P.G.&E. also has a program under way for increasing hydroelectric power by 30,000 kw. As integration and growth of the system continues, the need for "quick pickup" steam stations and multiple boiler per turbine installation probably will decline. The future trend of steam station design in California and elsewhere is expected to be in the direction of simplification of equipment and plant layout and still lower station heat rates.

Industrial Power Plant

Conant Dodge of the Weyerhaeuser Timber Co., and **C. W. E. Clarke** of United Engineers & Constructors, Inc., presented a paper on an industrial power plant recently constructed to supply electric power and process steam for the Weyerhaeuser Timber Co. at Springfield, Ore. The plant is designed for a present power load of 12,000 kw and process-steam loads of 95,000 lb per hr at 150 psig and 100,000 lb per hr at 40 psig.

The boilers, dust collectors, air heaters breechings, forced- and induced-draft fans, water-treating-system

tanks, filters, deaerating heater and motor-driven fire pumps are all installed out of doors. The operating space in front of the boilers includes fuel-handling equipment, gage boards and Dutch ovens, and is housed by a steel frame covered in the sides with corrugated asbestos and on the roof by precast cement channel tile, insulation board and built-up roofing. The turbine room and electrical bay are housed similarly directly adjacent to a corrugated partition along the boiler-operating aisle.

Three two-drum boilers are installed, each with a capacity of 85,000 lb per hr. They are fired by a three-cell Dutch oven burning hogged fuel and have superheater outlet conditions of 570 psig, 675 F. One boiler is equipped with oil-burning equipment for auxiliary fuel.

The combustion control system is actuated by the main-steam-header pressure to control fuel and forced draft. Fuel feed is also controlled by brilliancy meters which are electric eyes focused at the point where the gases cross the bridgewall. More fuel is fed as brilliancy increases and less as it decreases. First use of this method of control was at the Weyerhaeuser Klamath Falls plant, and its success there justified its installation in the new Springfield plant.

Approximately 50 per cent of the feedwater is condensate returned from the condensers and process equipment in the mill. Makeup water is treated by a single-stage, hot-process softener. Raw water is treated in a sedimentation tank, passes through filters and then is pumped to heaters. This type of treatment is used to control the unusually high silica content of the water.

Dust collectors are installed with each boiler to minimize discharge of ash and large cinders from the stack, thereby reducing fire hazards and preventing damage to finished lumber. The collected material is reinjected.

The generating equipment consists of two 11,500-volt, 3-phase, 60-cycle turbine-generators designed to operate at throttle steam conditions of 560 psig, 675 F. One machine is rated at 7500 kw and 0.8 power factor with extraction at 40 psig; the other at 5000 kw and 0.8 power factor with extraction at 150 psig. Both bleed points have constant-pressure control.

Fire protection in this type of plant is of utmost importance. A complete yard-piping system carries high-pressure water to all of the buildings in the area. To permit immediate attention to the five fire pumps, a fire-alarm system for the entire plant is centralized in the power station.

Refinery-Utility Power Stations

"History and Performance of Pacific Gas and Electric Company's Oil Refinery Steam-Electric Generating Stations" was the title of a paper by **V. F. Estcourt** of that company. Beginning with joint engineering studies in 1937, three steam-electric generating stations were constructed by P.G.&E. to furnish process steam and electricity for the Tidewater-Associated, Shell and Union Oil Companies and to supply firm power for the transmission system of the utility. Each plant operates at 1500 psig, 940 F and includes a single 50,000-kw, 3600-rpm tandem-compound turbine with automatic extraction at the exhaust of the high-pressure element. The turbine can be operated either straight condensing or as an automatic extraction machine.

The contract provides that the utility supply process steam and electricity in return for which the oil companies furnish certain quantities of "substitute fuel" and make cash payments based upon a demand charge plus a commodity charge. The definition of substitute fuel is "any liquid or gaseous fuel, including refinery waste fuel such as acid sludge, tars, waxes and gases which will not leave an unburnable residue in excess of two per cent by weight, and will produce substantially the same output of steam from the boilers as when fired to capacity with fuel oil."

Due to the burning of waste fuels, boiler availability is less than is attainable with good commercial fuels, but continuity of service is also important. In each plant there are three boilers per turbine, each with a continuous capacity of 200,000 lb of steam per hour and an overload capacity of 230,000 lb per hr. Due to the base load which must be carried to meet the demand for process steam, the loss of one boiler results in an electric load reduction of more than 50 per cent.

Improved Availability with Acid Sludge

Early experience with the burning of acid sludge resulted in low boiler availability due to external fouling of the heating surfaces. This fuel also required gas or oil pilot fires to sustain combustion. However, research has now made it possible to burn modified acid sludge with fairly high boiler availability.

The main problem associated with burning pitch or cracked asphalt is that of keeping its temperature at approximately 400 F in order to obtain satisfactory viscosity. So-called recovered oil is an end product from the manufacture of lubricating oil and is highly corrosive. To burn this and similar fuels of high sulfur content it is necessary to provide for partly by-passing the air preheater so that the exit-gas temperature can be held well above the dew point.

The characteristic of the ash content in high sulfur fuel oil produces a fouling problem which is quite different from that usually experienced with coal, because the ash fusion point is around 1600 F. Therefore the first bank of superheater tubes were fanned out so that spacing at the bottom was increased from $3^1/_2$-in. to $4^1/_2$-in. centers for $2^1/_2$-in. O.D. tubes.

Before making this change the fouling zone was concentrated initially in the first bank of the superheater, and as the deposits continued to build up, the temperatures were ultimately raised on the second bank to the point where fouling would commence in that zone. Effective soot blowing was impossible with the original close spacing, but after the tubes were fanned out the amount of fouling in the first bank and the first three rows of the second bank was materially reduced. It was then possible to keep these tubes clean by soot blowing.

Turbine-Generator Heat Rate Tests

A paper by **V. S. Renton** of Public Service Electric & Gas Co. and **Stanford Neal** of General Electric Co. discussed heat rate test results on a 3600-rpm, tandem-compound, 100,000-kw turbine-generator. When this unit was placed in service on December 18, 1947, at the Essex Generating Station, Newark, N. J., it was the

largest machine of its type built up to that time. Results of the tests were consistent with and slightly better than the guarantees.

Steam conditions at the turbine throttle are 1250 psig, 1000 F. The high-pressure section has 19 stages with extraction connections from the 7th, 10th, 13th, 16th and 19th stages. The double-flow, low-pressure section is on the same shaft and has 5 stages with extraction connections from each of the two 20th, 21st and 22nd stages.

The main generator is rated 111,765 kva at 0.85 power factor with 15 psig hydrogen pressure and 117,646 kva at 0.85 power factor with 25 psig hydrogen pressure. The house or auxiliary generator is air cooled and rated at 7500 kw at 0.80 power factor. The turbine and the two generators are solidly coupled to one shaft, and the unit has an overall length of 77 ft, $7\frac{1}{2}$ in. and weighs 1,120,000 lb.

Test data disclosed that the throttle steam rate is about 4 per cent better at 35,000 kw than at 117,000 kw, while the heat rate is about 9 per cent poorer at the lower load. This apparent inconsistency is explained by the amount of steam extracted for feedwater heating which changes from about 22 per cent to 32 per cent over the same range of load. The larger percentage of condenser steam flow at 35,000 kw has the effect of reducing the amount of throttle steam per kilowatt-hour at the expense of a less efficient cycle with its higher heat rate. This example shows that a low throttle steam rate is not necessarily compatible with a low heat rate. Had this turbine been operating non-extracting, the steam rate would have been the same for both throttle and condenser flows.

The lowest heat rate of the turbine-generator and feedwater heaters was found to be 8498 Btu per kwhr at a load of 93,000 kw and an exhaust pressure of $1\frac{1}{2}$ in. Hg. This is on the basis of the standard cycle used to compare test points and corresponds to a thermal efficiency of 40.16 per cent. Test data on the complete unit including boiler, turbine, feedwater heaters and auxiliaries, indicate an approximate overall heat rate of 10,100 Btu per kwhr at the most economical point during winter conditions, the corresponding thermal efficiency being 33.79 per cent.

For the entire year of 1948, the station records show that the overall unit heat rate was 10,500 Btu per kwhr at an average load of 97,800 kw for each hour of operation.

During the tests initial steam conditions were held as closely as possible to the rating of 1250 psig and 1000 F. At the lighter loads the boiler characteristics resulted in lower throttle conditions, the temperature being held within -10 deg F and the pressure within -10 psi.

All tests at exhaust pressures of $1\frac{1}{2}$ in. Hg were of two-hour duration. Those at other exhaust pressures were one-hour tests. To insure constant conditions, the load was set and held for one hour before the test period.

Adaptation of Cylindrical Furnaces

In a paper by **O. F. Campbell** of the Sinclair Refining Co., East Chicago, Indiana, on "Cylindrical Furnaces for the Petroleum Industry," mention was made of the application of the cylindrical furnace to a steam boiler by the Petro-Chem Development Co. One design incorporates a vertical steam drum instead of the conventional horizontal drum. The steam and water mixture from the fired boiler tubes enters the vertical drum horizontally, where it is given a rotary motion by baffling for the separation of water from steam. The steam liberating surface is therefore a hollow cylinder of water in the vertical plane around the circumference of the drum, and the boiler drum is a vertical centrifugal separator.

Four of these units, which are designed for 400 psig and 30,000 to 50,000 lb of steam per hour each, are in operation. The boiler is bottom supported by the tubes, and the circulating return or downcomer, which is located in the furnace, is insulated to prevent it from becoming a riser. The bottom end of the steam drum is surrounded by flue gases and does not require insulation. If superheated steam is required, a separately fired superheater can be used.

Atomic Power Plant Instrumentation

Operation of the first atomic power plant probably will be limited because of inadequate development of instruments that can be used in areas of intense radiation and high temperature according to **David Cochran** and **C. A. Hansen** of the Knolls Atomic Power Laboratory of the General Electric Company. The biggest obstacle to development of instruments for operating and maintaining an atomic power plant is lack of instrument testing facilities. Only a few places exist in the country where the effect of radiation on materials and devices may be studied or where liquid metal cooling systems are available for instrument testing, And nowhere is there a combination of radiation and high temperature liquid metal such as will exist in the practical application of the atomic power plant.

As yet there are no demonstrated solutions to the unusual problems of applying instruments in an atomic power plant, but more and better testing facilities now are being built and this should speed up development of instruments. Instruments are needed in the plant for control and safety of plant operation; for observing the condition and behavior of the plant as its operation proceeds; and for monitoring radiation leakage in the plant to insure protection of operating personnel. To do these jobs, detecting devices must meet requirements not found in conventional power plant applications, where the problem of a radioactive zone is not present. Such requirements include extreme dependability, remote maintenance, resistance to neutron and gamma radiation, absolute leak tightness and long service.

"The grave consequences of an uncontrolled nuclear reaction make it mandatory that instruments and controls function properly and dependably," the authors asserted. "There is nothing about a nuclear reactor that corresponds to the safety valve of a steam boiler in the conventional power plant. The nuclear reactor has a definitely limited capacity for absorbing or dissipating extra energy, so there must never be a runaway condition of the nuclear reaction."

Maintenance by remote control is necessary, since it is not possible to perform direct inspection and maintenance work on the detecting devices within the radioactive zone. When a failure occurs it may be necessary to remove and replace the instrument by means of remotely operated equipment. If the device has become radio-

active in service it usually cannot be repaired after removal but must be replaced with a new unit. Where the detecting elements are very difficult to remove or are completely inaccessible, stand-by detecting elements must be installed at the time the plant is built.

Resistance to radiation is vital because pressure, temperature and flow detectors must function correctly in the presence of tremendous radiation. Continued exposure to radiation must not cause such physical deterioration of the device as to change its performance in a way that cannot be determined and compensated for. Also, devices to detect chemical contamination of the coolant must function in spite of the radioactivity of the coolant.

Furthermore, detecting elements exposed to the coolant or blanket gas must be absolutely leak tight, for the escape of even minute quantities of radioactive coolant may cause a serious hazard. Similarly, if the blanket gas contains any gaseous fission products or radioactive dust particles, the leakage of gas may be very hazardous.

Synthetic Fuel Costs

The cost of producing synthetic liquid fuels has dropped to the point where refined products, such as gasoline, diesel oil and heating oil, can be made from coal and oil shale for as little as 8.4 to 12 cents a gallon, excluding interest on plant investment and profit, according to **W. C. Schroeder,** chief of the Office of Synthetic Liquid Fuels, U. S. Bureau of Mines. The plant investment would be between $7000 and $8500 for each barrel of capacity per day for plants of 10,000 barrels capacity and over, he said.

The cost of crude shale oil, again excluding interest on investment and profit, is approximately $2 per barrel. From this the speaker estimated that the cost of gasoline, diesel oil and heating oil made from the crude shale oil would be about 8.4 cents per gallon. Initial plant investment would be between $4000 and $5000 per barrel per day capacity.

Developments in mining and processing oil shale have been largely responsible for the low production cost of refined oil shale products. Progress in refining oil shale also has been substantial and indicates that 75 to 85 per cent of crude shale oil can be converted economically into gasoline, heating oil and diesel fuel. Retorting of oil shale, while essentially a simple heating process, still needs considerable study to determine the most efficient equipment.

Shortages of gasoline and fuel oil common during World War II and the immediate post-war period are no longer a problem. In spite of high-level consumption, the petroleum industry has raised production fast enough to overtake demand and even provide some excess of oil products. "It does not follow, however, that domestic surpluses necessarily will be of long duration in the face of increasing consumption per capita and an increasing population," Mr. Schroeder cautioned. "In less than a decade, shortages of domestic petroleum can appear that would grow rapidly."

Four courses available to meet these shortages are importation of oil, secondary recovery, development of tidelands oil and development of synthetic liquid fuels. Probably the most important of these is development of synthetic liquid fuels. This would insure a liquid fuel supply independent of foreign sources and adequate for centuries as well as provide a new American industry.

Coal Burning Qualities

E. M. Naughton, of Utah Power & Light Co., contributed a paper on "The Burning Qualities of Utah-Colorado-Wyoming Coals" to the panel discussion on "Coal for West Coast Power Generation." In comparison to eastern coals, western coals are generally low in ash and sulfur contents, while they tend to be higher in moisture and volatile matter. Due to higher moisture content, the calorific value is lower than some eastern coals.

Use of mechanical firing equipment in the Rocky Mountain area has closely followed the national trend. The largest underfeed stokers serve boilers of 175,000 lb of steam per hour at the Jordan plant of the Utah Power & Light Co. The largest traveling grate stoker in the area is capable of burning a maximum of 23,800 lb of coal per hour to produce 200,000 lb of steam at the Orem (Provo) plant of the same utility. Spreader stokers have also been used, the largest being applied to a boiler having a capacity of 120,000 lb of steam per hour.

The principal difficulties encountered in stoker operation result from lack of recognition that the same amount of coal cannot be burned per square foot of grate surface at altitudes in excess of 4000 ft as can be burned at sea level. Proper sizing of gas passage through boilers is also important at high altitudes.

Most of the coals of the region have been burned quite successfully in pulverized form, the first installation having been made in 1924 at the Valmont plant of the Colorado Public Service Co. This installation employs the bin system and has burned both lignite and sub-bituminous coals. At the Orem plant of the Utah Power & Light Co., a 450,000-lb-per-hr, 1050-psig, 950-F boiler is now being erected and is designed to burn pulverized coal and oil.

In concluding, Mr. Naughton expressed the belief that vast quantities of Utah-Wyoming-Colorado coals could be successfully used in West Coast boilers. If both bituminous and sub-bituminous fuels are to be burned, capacities of grate areas or pulverizing mills should be selected for fuels of lower heating values to avoid excessive cinder emission or lack of mill capacity. Care should also be taken to have sufficient furnace volume to keep exit gas temperatures below minimum ash softening temperatures.

Burning Wet Wood

"Some Recent Developments in Burning Wet Wood" was the title of a paper presented by **Otto de Lorenzi** of Combustion Engineering-Superheater, Inc., a full abstract of which will appear in a forthcoming issue of COMBUSTION. Use of the two-stage furnace, comprising a Dutch oven and a secondary combustion chamber, has been generally accepted as standard for "hog fuel" and other kinds of wet wood refuse. Recently, however, large scale experimental installations of the single-stage furnace using both underfeed and spreader firing have been operated successfully. As a result of these developments there are now available, for many types of installations, simplified combustion systems having high inherent capacity, to which automatic controls may be easily applied.

Health Aspects of Air Pollution*

By A. J. LANZA, M.D.

Let us ask ourselves what is pure air and where is it found. Presumably pure air is air containing only its chemical components in proper proportion and free from any air-borne foreign substances whatever. Pure air might possibly be found on mountain tops and in mid ocean. Wherever man goes or congregates he pollutes the air, first of all by the process of breathing and secondly by his habits and customs. For one thing, he draws an enormous amount of tobacco smoke into his lungs and respiratory passages which he thereafter exhales for the benefit of his fellow man. He moves around in millions of motor cars which, in their mass effect, contribute more to the pollution of the atmosphere, particularly at the breathing level, than do the factory stacks.

These facts are not presented in any way as an extenuation of the air pollution problem, but merely to point out that there are definite aspects of the problem which must be kept in mind if we are to introduce a leaven of common sense into our discussions.

For one thing nature has constructed the breathing apparatus of man so that it is a fairly effective filter of extraneous matter that may be suspended in the air. For centuries before the industrial era, man breathed air contaminated by foreign particles arising from the surface of the earth and stirred up by wind and by agricultural pursuits and by the processes of nature, such as pollinization of trees and flowers. Man has been contending with air pollution ever since he left the garden of Eden. He has survived, not on y because of his own defensive mechanism but because the movement of air has diluted his various exposures to air-borne substances sufficiently to render them harmless, or at least tolerable.

What faces us now is that, on account of the enormous expansion of industry, and our methods of heating homes and office buildings, we are in many instances faced with the realization that we cannot continue to rely entirely on the benign effects of nature to protect us. At the same time we should endeavor to understand our problem as clearly as possible so that we do not become the victim of needless fears and worries.

The common industrial poisons do not affect the general population as a result of atmospheric pollution. In spite of automobiles there does not seem to be a hazard of carbon monoxide poisoning in the general atmosphere and when cases of illness from toxic substances do occur, usually they result from intimate contact in the home. On rare occasions mother nature has played us false, and we have had the chain of circumstances that contributed such episodes as Donora, and the series of fatalities in the Meuse Valley in Belgium in 1930. Of lesser degree are the episodes of smog with eye irritation in Los Angeles and some similar events in other parts of the country. It might be agreed that pollution of the atmosphere by fumes and gases of industrial origin sometimes may give rise to a serious situation; also that from time to time it can cause serious annoyance to large groups of people; and also that where it does not cause direct ill effects, such as irritat on of the eyes or upper respiratory system, it frequently does have a considerable nuisance value.

Such nuisances are a real detriment to any community and are a challenge to all who are concerned with control measures, either as private individuals or as official governmental agencies. It is not the purpose of this discussion to describe what measures should be taken, but control is more and more a matter of concern to all of us. It is the right of everyone to be free from discomfort or nuisance either in his home environment or in the locality in which he may make his living.

Air Pollution Disability

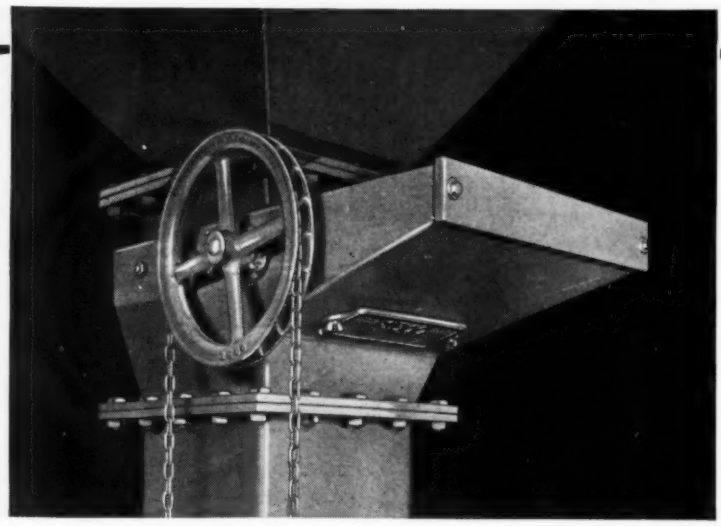
The amount of disability and mortality from these causes is exceedingly small, so small that it could not be identified in any statistical tabulation of the causes of death or disability. It is not true that the air of our communities contains lethal or disabling amounts of a large variety of toxic substances poured out upon a defenseless community by the neighboring industries. Our communities may be death traps, but not from atmospheric pollution.

We are justified in making a plea for a considered and intelligent viewpoint in the matter of atmospheric pollution. Not only do fallacious and scarehead pronouncements by irresponsible persons do no good. They may do more harm to the comfort and well-being of communities than the ills they pretend to discuss.

For the most part, the visible agent in atmospheric pollution is smoke which consists mainly of carbon and other combustion products. Smoke may be a nuisance, a very considerable nuisance, and is being so recognized to an increasing extent. Here again, without in any way minimizing the nuisance value of smoke to general comfort and well-being, smoke pollution can become the occasion for many loose and injudicious statements.

A recent memorandum dealing with smoke pollution in New York City attempted to substantiate the claim that smoke is an important cause of cancer of the lungs. Dr. L. I. Dublin, noted medical statistician, has characterized it as an example of the misuse of statistics for propaganda. He writes, in part: "Atmospheric pollution may or may not be a cause of cancer of the respiratory organs. At the

* Excerpts from a paper presented on May 24, 1949, at the 42nd Annual Conference of the Smoke Prevention Association of America. Dr. Lanza, is chairman of the Institute of Industrial Medicine, New York University-Bellevue Medical Center.



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present time our knowledge of the subject is mostly conjectural. We have no authoritative statistics that would indicate an affirmative conclusion."

Some years ago there was considerable discussion as to whether smoke pollution was responsible in part for the mortality from pneumonia. From 1911 to 1913 the Mellon Institute conducted, in Pittsburgh, the first comprehensive study of the smoke problem in this country.

In 1912 Dr. Marcy and Dr. White reported that those districts of Pittsburgh which had the greatest soot fall also had the highest incidence of pneumonia. In 1923 and again in 1929 these observations were confirmed by Dr. Meller. In 1938 Dr. Hagthorn and Dr. Meller published a report, "The Necropsy Evidences on the Relation of Smoky Atmospheres to Pneumonia." They based their report on the post-morten examination of the lungs of 3000 persons dying from various diseases in Pittsburgh hospitals, including women, children and men variously employed in the professions and in industry.

This report was made before the advent of chemotherapy robbed pneumonia of most of its terrors. Nevertheless it furnishes information applicable to our problems today. In their conclusions the authors stated that nothing tangible was found to connect the pigment deposits in the lungs examined with pneumonia incidence or mortality rates.

Conclusions

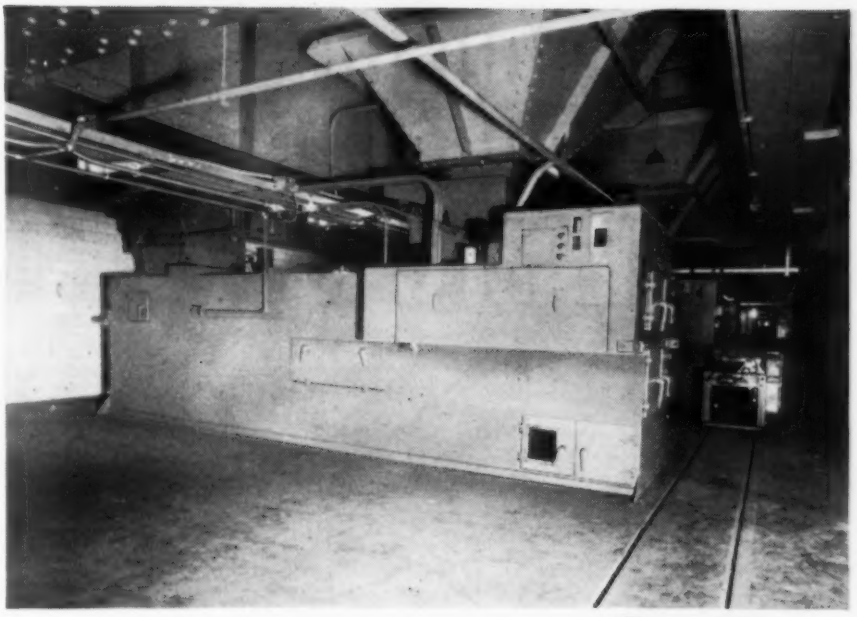
What may we conclude from the evidence so far available?

1. Industrial fumes and gases do not occur in the general atmosphere to an extent to cause disability or death, except in very unusual and rare instances.
2. Industrial fumes and gases may constitute a nuisance and even at times irritation and inflammation of eyes and upper air passages.
3. As we cannot control the weather, every possible means must be taken to guard against dangerous or annoying episodes.
4. Smoke pollution, aside from its economic aspects, is a nuisance. It can seriously interfere with general well-being and comfort. That it can cause specific disease or death to any considerable degree cannot be stated in the light of available evidence.
5. Every resource of engineering science and practice should be employed to provide an atmosphere free from annoying or dangerous impurities.

Electric Output and Fuel Stocks High in May

Production of energy by electric utilities during May, according to the Federal Power Commission, totaled 23,348,224,000 kwhr, which was the highest May output on record and 3.3 per cent over that of May 1948 or 0.6 per cent above April 1949. Of this total, water power was responsible for 34.5 per cent and fuel-burning plants 65.5 per cent.

For the twelve months ending May 31, 1949, the aggregate output was 287,909,644,000 kwhr, or an increase of 8 per cent over the preceding twelve months.



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KEYNOTES EFFICIENCY

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Efficiency and simplicity keynoted the design and construction of Public Service Electric and Gas Company's new, 450,000 kw. Sewaren Generating Station. To keep building and operating costs down, four semi-outdoor type boilers supply steam at 1050° F., the highest temperature to be utilized commercially. To keep tab on coal consumption, 12 self-testing, elongated type, Richardson Automatic Coal Scales were installed.

An 1800-ton bunker supplies coal for each boiler. Four of the 12 Richardson Scales weigh and feed coal to three pulverizers, each of which is fed from either of two scales. When required, coal can be by-passed through a motor operated gate direct to the pulverizer or to a shuttle conveyor for delivery to adjacent boilers. Dust-proof construction of scales withstands pressure equal to 40 inches of water, confines coal dust to scale housing, contributes substantially to cleanliness of the plant.

For over 40 years Richardson Automatic Coal Scales have been helping central stations and industrials eliminate preventable coal waste and produce more power at less cost . . . a good reason for calling on Richardson when you plan to modernize your present plant or build a new one.

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For further details on Richardson Coal Scales, write for Bulletin No. 1143-C.

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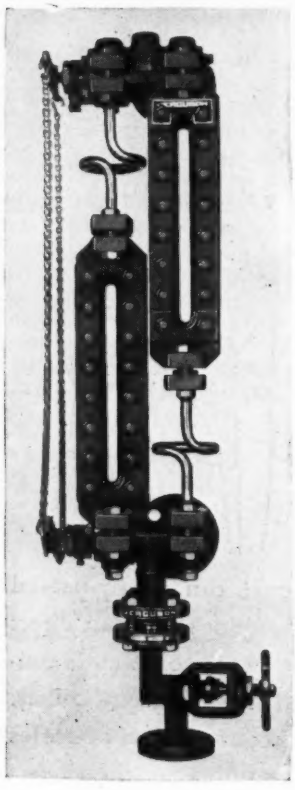

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In fact, it was the highest total of any twelve-month period to date.

Reports received by the Commission indicated a net increase of more than 335,000 kw in installed capacity of electric generating plants in utility service during May 1949, which brought the total, as of May 31, up to 58,201,883 kw.

Industrial electric production, including railway plants, was 4,526,492,000 kwhr during May, which represented an increase of 2.3 per cent over the same month last year. The total industrial generating capacity at the end of May was 13,242,579 kw.

The same source reports electric utility power plants as having consumed 13.8 percent less coal in May 1949 than a year previous, and 2.8 per cent under that of April 1949. On the other hand, both gas and oil consumption mounted to new high levels. The former was 15.8 per cent over May 1948, and the latter was 40.9 per cent over May 1948.

Stocks of coal, as reported by the electric utilities on June 1 totaled 28,078,522 tons, which was 68 per cent more than the stocks on hand a year previous and sufficient, on the average, for 118 days' operation. Fuel oil stocks were sufficient for 60 days.

James D. Cunningham Nominated to Head A.S.M.E.

James D. Cunningham, president of Republic Flow Meters Co., Chicago, is the 1950 nominee for president of The American Society of Mechanical Engineers. He heads a slate of new officers, including four regional vice presidents and two directors-at-large, submitted by the nominating committee during the society's Semi-Annual Meeting in San Francisco, June 27–July 1.

Formal election will take place in the fall by letter ballot of the membership, which totals more than 25,000 engineers throughout the United States. Mr. Cunningham and the new slate of officers will begin their terms at the end of the A.S.M.E. annual meeting in New York next December.

Born in Chicago in 1887, Mr. Cunningham began his industrial career as a clerk for Armour Glue Works, after graduating from Hyde Park High School in 1905. He served as vice president of the Clyde Machine Works Co. from 1909 until 1911 when he left to found and become president of the Steam Appliance Co., now Republic Flow Meters Co., manufacturers of industrial instruments and controls.

During World War I, Mr. Cunningham served as a second lieutenant in the Air Service, U. S. Army. He is a director of the Autogas Co., Baltimore and Ohio Railroad Co., Belden Manufacturing Co., Lake Shore National Bank and Lumbermens Mutual Casualty Co., Public Service Company of Northern Illinois and Allis-Chalmers Manufacturing Co. Also, he is a member of the Western Society of Engineers, Illinois Manufacturers Association, and the Chicago, Union League, Commercial and Indian Hill Clubs.

Regional vice presidents nominated are:

Frank M. Gunby (renomination) of Charles T. Main, Inc., Boston.

Professor John C. Reed, head of mechanical engineering department, Bucknell University, Lewisburg, Pa.

Albert C. Pasini, assistant superintendent, production department, Detroit Edison Co., Detroit.

Samuel H. Graf, director, engineering experimental station, Oregon State College, Corvallis, Ore.

Nominated as directors-at-large:

Thomas E. Purcell, general superintendent, power stations, Duquesne Light Co., Pittsburgh.

Benjamin P. Graves, director of design, Brown & Sharpe Mfg. Co., Providence, R. I.

F. A. Schaff Gets Doctor Degree

Frederic A. Schaff, chairman of the board of Combustion Engineering-Superheater, Inc., was honored by his Alma Mater, Purdue University, with the degree of Doctor of Engineering, at the Ninety-First Commencement on June 19. Pre-

sentation was by Dean A. A. Potter in recognition of "contributions to the design and production of equipment harnessing power for the benefit of mankind."

Following graduation from Purdue with the class of 1907, Mr. Schaff was for several years engaged in railroad work with the New York Central and the Boston and Albany, and in 1913, joined the Locomotive Superheater Company, later rising to the position of vice president. When that company was later succeeded by The Superheater Company, he became its president. He also was made president of Combustion Engineering Company in 1933, and subsequently its board chairman. With merger of the two companies on January 1, 1949, he became chairman of the board.

Mr. Schaff is a fellow of the American Society of Mechanical Engineers and has long been active in railway and power plant circles.

Simplicity itself, the cotter, and certainly not costly . . . yet as indispensable to complete security as it is unsurpassed for the service intended.

So, too, with Dampney protection. In boiler tubes and drums, where we initiated our program of maintenance for metal some thirty years ago, APEXIOR NUMBER 1 surfacing continues unexcelled as a simple, inexpensive means of securing a major investment.

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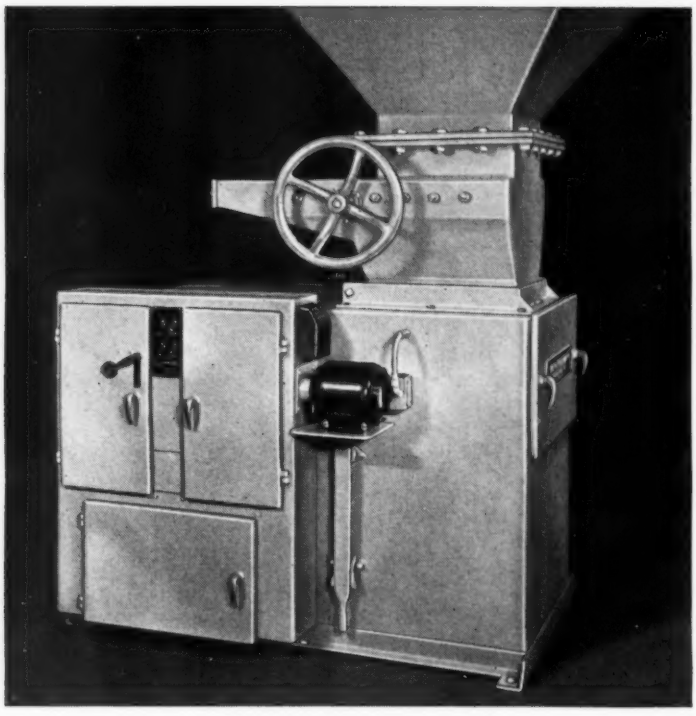

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Accuracy is the paramount requirement of any scale. The steel weigh lever system, steel loops, hardened steel pivots and bearings used in S-E-Co. Scales, give a minimum weight to these parts. This light weight means low inertia, faster action, and therefore greater accuracy. Only S-E-Co. Scales are equipped with light weight steel levers and loops.

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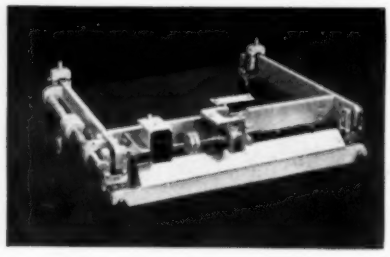


Write for Bulletin

STOCK ENGINEERING COMPANY

715C Hanna Building ★ Cleveland 15, Ohio

John Van Brunt Honored

John Van Brunt, vice president of Combustion Engineering Company for more than a quarter of a century, and since January 1, 1949, engineering consultant for Combustion Engineering–Superheater, Inc., was awarded the degree of Doctor of Engineering by Stevens Institute of Technology at its 1949 Commencement exercises on June 11.

A graduate of Stevens with the class of 1897, Mr. Van Brunt has devoted his entire career to the power plant field. He has been responsible for the design

of many of the largest and most efficient steam generating units now in operation in this country and has long been regarded as an authority on fuel-burning equipment. He is a registered professional engineer of New York State, a fellow of the American Society of Mechanical Engineers, a member of the American Society for Testing Materials, and has served on many important technical committees.

Obituary

Anderson W. Harris, for a number of years past in charge of fire-tube boiler and fabricated product sales at the Chattanooga Division of Combustion Engineering-Superheater, Inc., died suddenly of a heart attack on June 2. His entire adult career had been spent with that company and its predecessors.

Born September 4, 1882, Mr. Harris entered the employ of the Walsh-Weidner Boiler Co. in Chattanooga, in March 1907. Two years later he changed over to the Casey-Hedges Boiler Co. in the same city as an estimator, and when that company merged with Walsh-Weidner in 1924, he became identified in a sales capacity with the Hedges-Walsh-Weidner Co. In September 1928, this company was taken over by Combustion Engineering, and Mr. Harris was put in charge of fire-tube boiler and fabricated products sales in Chattanooga. Long an active member of the A.S.M.E., he was one of the organizers of its Chattanooga Section.

Business Notes

Dearborn Chemical Company, Chicago, has added Edward S. Bus to its sales staff. He will have headquarters in Seattle and take over the Washington-Oregon territory.

The **Whiton Machine Company,** New London, Conn., announces the promotion of Stanley E. Peterson to vice president and secretary, and of Walter E. Beaney to vice president and factory manager.

Edward Valves, Inc., East Chicago, Ind., has appointed Thomas J. Williams sales engineer for the southwestern states. His headquarters will be in Tulsa, Okla.

Manning, Maxwell & Moore, Inc., Bridgeport, Conn., has appointed C. F. Johnson manager of valve sales.

William W. Hopwood has been elected vice president of **Hagan Corporation,** Pittsburgh, Pa., and its subsidiaries—Calgon Inc., Hall Laboratories, Inc., and the Buromin Co.

Globe Steel Tubes Co., Milwaukee, announces the promotion of F. K. K. Krell to manager of sales for welded fittings; J. F. Scott manager of sales for stainless and alloy tubing; appointment of John Koss as sales representative in the Chicago district; and J. J. Lukens as sales representative in the New York district.

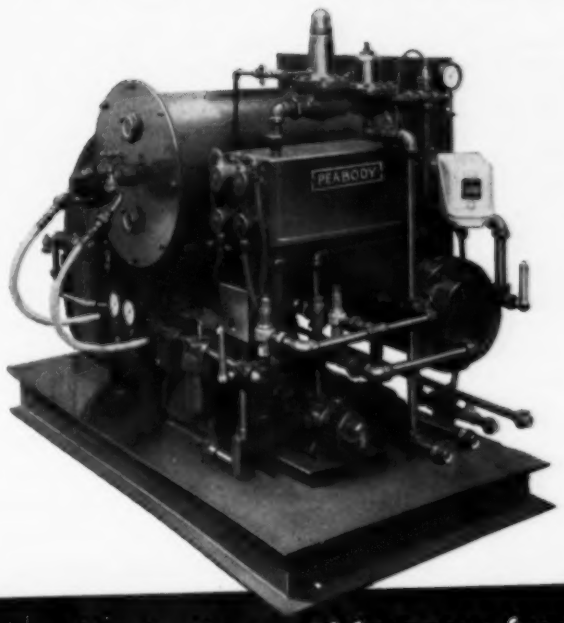
New District Sales Office

Combustion Engineering-Superheater, Inc., has appointed H. D. Nickle as manager of a new district office for the Northwest territory including the states of Washington and Oregon. It is in the Skinner Building, Seattle, Washington.

Fabian Bachrach

Mr. Nickle, a mechanical engineering graduate, joined Combustion Engineering Corp., Ltd., of Canada, in 1937, as manager of service and erection in Montreal. Later he was engaged in contract work and in sales relating to the pulp and paper industry. In 1945, he was transferred to the New York Office of Combustion Engineering-Superheater, Inc., in charge of Paper Mill Division sales.

A COMPLETE AUTOMATIC OIL BURNER SYSTEM



to fire boilers and furnaces from 100 developed HP upward

If you're interested in improved plant layout, low operating costs, and reduced overhead on your heating and power plant installations, you'll be interested in the Peabody Automatic Burner. Designed, built, and engineered by Peabody, the Automatic Oil Burner is a compact, complete oil combustion system that takes Bunker "C" or lighter oils from your storage tank, pumps it, preheats and delivers it to the burner at the proper viscosity and then burns it at the specified firing rate dictated by operating demands.

DEPENDABLE

The Peabody Automatic Burner is listed by Underwriters' Laboratories, Inc. and has a complete system of checks, safeguards, and automatic controls to maintain the required firing rate that assures maximum efficiency and safety at all times. Available for both fully-automatic and semi-automatic operation.

READY TO INSTALL

The entire assembly is mounted at the factory on a common base. No extra construction or engineering necessary to put it into operation. Just bolt it to furnace front, and make necessary service connections. It's simple, safe, and dependably economical!

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Manufacturers of all types of combustion equipment, direct-fired air heaters, gas scrubbers, coolers and absorbers.

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OFFICES IN PRINCIPAL CITIES

New Catalogs and Bulletins

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Anti-Foam Treatment

A 4-page bulletin describing anti-foam treatment No. 659 has been released by Dearborn Chemical Co. Prepared in a powder form, this material is one of the polyamide type compounds used to condition sludge and improve steam quality. The bulletin also includes illustrations from high-speed motion picture studies showing the action of polyamides during the formation of steam bubbles.

Ash Bins

Allen-Sherman Hoff Co. has issued a 3-page catalog, No. 4240 illustrating the "A-S-H Dehydrating Hydro-Bin." Representative installations are shown, and features of water collecting anti-freeze gates are explained.

Car Shakeout

Bulletin No. 130 describes a new, lighter-weight Robins car shakeout, Model GS, manufactured by the Robins Conveyors Division of Hewitt-Robins, Inc. The unit is designed to unload up to 15 hopper-bottom cars of granular material per day. The 4-page bulletin illustrates typical applications and emphasizes money, time and labor savings.

Centrifugal Pumps

An informative 16-page bulletin on the care of centrifugal pumps has been prepared by Allis-Chalmers. It gives the how and why of pump construction and their effect on pump maintenance. The booklet tells how suction piping should slope, indicates common mistakes in packing stuffing boxes, explains how to figure head and mentions causes and cures for various sources of troubles. Other subjects covered are the rôle of water as a lubricant in pumps and little-known facts about cavitation.

Coal Scales

Features of a new line of automatic coal scales manufactured by the Stock Engineering Co. are explained in a 14-page bulletin just issued. Numerous illustrations are included to depict details of the equipment and to represent its manner of operation. The scales consist essentially of a belt feeder, weigh lever with necessary attachments and a weigh hopper. Typical installations range from 10 tons per hr per scale in industrial plants to 20 tons per hr per scale for central station use.

Coal Distributor

Bulletin No. 1349 describes the "Monorate" nonsegregating coal distributor for stoker firing manufactured by the Richardson Scale Co. Cross-section diagrams provide a comparison between conventional coal spouts and the "Monorate" distributor. Illustrations are used to show the engineering principle involved. The 4-page bulletin also shows typical installations for stokers and pulverized-coal firing.

Diaphragm Control Valves

Series 700 diaphragm control valves is the subject of a 32-page catalog published by the Minneapolis-Honeywell Regulator Co., Belfield Valve Div. The mechanical and flow characteristics of this air-operated diaphragm, motor-controlled valve are featured, as well as the standard and special control applications for diverse operating conditions. Dimension tables and ratings, shipping weights and cubical measurements are also included. A section is also devoted to pilot piston control valves with flow charts, sizes and dimensions.

Direct-Fired Air Heaters

A six-page bulletin in four colors illustrating direct-fired air heaters has been issued by Peabody Engineering Corp. There are flow charts in full color and cross-section drawings. Typical installations for spray drying, tunnel drying and odor elimination are illustrated. The bulletin will be of interest to those in fields where closely controlled high-temperature atmospheres are required in processing.

Flow Meters

Two Bulletins, 400-F1 and 400-F2, have been prepared by Builders-Providence, Inc., to explain the features of "Shuntflo" meter Models SMKS and SMDH. Model SMKS is designed for measurement of steam, air or gas flow in 1- to 12-in. lines, while Model SMDH is for use in 1- and $1^1/_2$-in. lines. The bulletins include correction factor charts and capacity tables for saturated steam, air and gas.

Over-Fire Air Jets

Plibrico Jointless Firebrick Co. has issued a 4-page brochure on the "PliOjet" system for smoke abatement. This system is manufactured in ten standard sizes ranging in firing rate from 96 lb of coal per hour to 3900 lb of coal per hour and from two to sixteen jets. Control equipment is discussed along with the effectiveness of over-fire jets in reducing smoke emission.

SAUERMAN For Better COAL STORAGE at LOWEST COST

Scrapers Simplify Stockpiling

Faced with problems of storing more coal without using more labor, your answer is a Sauerman Power Scraper System, requiring only one man at the controls.

LET US SHOW YOU ACTUAL RESULTS. Hundreds of plants using Sauerman Systems, are storing and reclaiming coal at only a few cents per ton. All available space utilized. Coal piled higher in compact layers. No segregation of lumps and fines. No air pockets for spontaneous combustion. Far less dust and dirt.

Whatever your tonnage, large or small, a Sauerman System can make important savings in handling costs. SEND FOR CATALOG.

The above stockpile, probably the largest at any power plant in the world, is handled by a Sauerman Scraper System equipped with a 10 cu. yd. Crescent bucket which stores and reclaims at the rate of 400 t.p.h. The storage area is a segment of a circle with a radius of 575 ft., around which moves a remotely controlled tail tower. The scraper hoist, too, is remotely controlled by means of an electro-hydraulic unit designed by Sauerman engineers. One man handles the entire operation.

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